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# Elisha Mitchell Scientific Society

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# TABLE OF CONTENTS

JOURNAL

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VOL. XXV NO. 1

## PROCEEDINGS OF THE ELISHA MITCHELL SCIENTIFIC SOCIETY, NOVEMBER 1907 TO MARCH 1909

### 173RD MEETING, NOVEMBER 12, 1907

*W. C. Coker:* A Trip to Porto Rico. Illustrated with lantern slides and many botanical specimens.

### 174TH MEETING, JANUARY 10, 1908.

*Dr. Styles*, of the U. S. Marine Hospital Service, lectured on "The Condition of Cotton Mill Operatives in the South."

### 175TH MEETING, JANUARY 14, 1908.

*H. V. Wilson:* Some Phenomena of Coalescence and Regeneration in Sponges.

*Chas. H. Herty:* The Volatile Oils of *Pinus taeda* and *Pinus echinata*.

*Chas. H. Herty:* The Analytical Control of Cotton Seed Oil Manufacture.

### 176TH MEETING, FEBRUARY 12, 1908.

*Collier Cobb:* The Cause of Earthquakes in the Light of Recent Earthquake Action. Illustrated.

177TH MEETING, MARCH 31, 1908.

*Archibald Henderson:* Photography as a Fine Art.

*A. S. Wheeler:* Color Photography.

178TH MEETING, APRIL 28, 1908.

*William Cain:* Stresses in Masonry.

*Wm. DeB. MacNider:* Pathololological Effect of Alcohol upon Animals.

BUSINESS MEETING, SEPTEMBER, 22, 1908.

The meeting was called to order by President Coker. The following officers were elected to serve for the ensuing year.

*President:* Archibald Henderson.

*Vice-President:* A. H. Patterson.

*Permanent Secretary:* F. P. Venable.

*Recording Secretary:* A. S. Wheeler.

*Editorial Committee:* W. C. Coker, Chairman; J. E. Latta, J. E. Mills.

179TH MEETING, OCTOBER 13, 1908.

*H. N. Eaton:* Results of the Microscopic Study of the Slate near Chapel Hill.

*J. E. Mills:* Chemical Energy.

*H. V. Wilson:* A Further Contribution on the Regenerative Power of Sponge Cells.

180TH MEETING, NOVEMBER 10, 1908.

*Chas. H. Herty:* Determination of Oil in Cotton Seed Products.

*Collier Cobb:* Geological Trip in Southern Europe in the Summer of 1908.

181ST MEETING, FEBRUARY 9, 1909.

*W. C. Coker:* A Visit to Luther Burbank in California. Illustrated with lantern slides and specimens of Burbank's productions.

A. S. WHEELER,
*Recording Secretary.*

# THE FOUNDATIONS OF SCIENCE*

BY J. E. MILLS

I have thought for years and the conviction has grown stronger with each passing year, that much needless confusion existed among scientists regarding those broad principles upon which all science is founded. The student of science at first accepts the various definitions, laws, theories, and explanations, with which he is fed, with either an unquestioning obedience, or with a feeling of utter helplessness. Later he finds that his first learned definitions, laws, theories, and explanations, are incomplete or faulty or open to question on various grounds. What guide has he enabling him to climb above the confusion ?

Chemists, certainly, have provided the chemists with none. There is an idea abroad among chemists that any discussions of the first and deepest principles of science are bound to be fruitless. Some chemists both act and talk as though they believed it a sin to look beyond and around the test tube which they hold in their hand. They imagine that they are thereby enabled to confine themselves to "facts" and they regard with more or less ill-concealed scorn the Brother chemist who refuses to be content with the fact but who insists on trying to obtain an explanation of the fact.

This attitude on the part of chemists, and it is true, I think, more particularly of American chemists, has to my mind been productive of a simply vast and untold amount of harm. For this attitude has discouraged the formal discussion, statement, and development, of the broad and underlying principles of science by scientists. We permit the philosopher to discuss these things but the philosopher too often lacks the knowledge and insight of

*Address of the President before the North Carolina Section of the American Chemical Society, Raleigh, N. C., Jan. 9th, 1909.

the scientist. We make a great mistake when we ignore, discourage, or ridicule the philosopher when he undertakes to consider the foundations of science. We should help him. Or rather we should absorb his knowledge. For the philosopher is trying to state certain broad principles underlying science and our ignorance of these first principles has led to a needless confusion, permitted many false explanations to become fastened on our science, and has turned many away from fruitful fields of investigation.

I have not overstated the case. I will give examples later of some of the many absurdities that are of every day occurence among us. But let us first consider briefly the origin of our knowledge.

There is a reality. No matter from what standpoint viewed, this much, we think, is admitted in all philosophies. There is, it seems to me, no more certain, and in fact no other ground upon which to rest such a conclusion than the "Cogito, ergo sum" of Descartes. I think, therefore I am. Our consciousness of the simplest mental act, of sensation, or of thought, or of volition, is sufficient to establish the fact. *Our first conclusion* is, that there is a reality. I think, therefore, at least *I* exist.

What more can we learn of this reality whose existence we are compelled to acknowledge ?

Our sensations are often deceptive and they may be always deceptive. Therefore we cannot trust them to give us any absolutely certain evidence about reality. Even were another sensation to be discovered we could never be sure that it would not likewise prove deceitful. The only thing of which I may be *absolutely* certain is that I exist. I think, therefore I exist. All else may be a dream. I may be the reality and the entire reality. There may be nothing but ideas, impressions. Or I may be but a part of one vast machine. We cannot with certainty condemn either the idealist or the materialist from this standpoint.

It has been pointed out that we have an equal right to declare, "Cogito, ergo cogitatio est", "I think, therefore thought is", which is true. But the conclusion that there is a non-ego as well as an ego—a thought as well as a thinker—does not necessarily follow. For when we come to consider the bottom of the matter the "thinker" and the "thought" may be one and the same thing.

True we have a very strong conviction that they are not the same thing, but this conviction is not absolute certainty. Since the actual nature both of the "ego" and of the "thought" is unknown, it becomes evident from the start that we cannot prove either their identity or their difference.

There is a reality—there absolute certainty ends. Upon this much all philosophers are practically agreed,

*The second step* in our search for knowledge is an assumption. Mathematics, physics, chemistry, all human knowledge, even reason itself, rests upon the following assumption:—

*Likenesses and differences exist and can be recognized by us.* If likenesses and differences did not exist and if you could not recognize these likenesses or differences you could not tell a friend from an enemy, you could not tell a good reason from a bad one, or a right conclusion from a wrong one.

Here science makes its start. The knowledge that we gain from day to day, or the knowledge that has come down to us from other laborers of other days, is derived mainly at least, and some believe that it is entirely derived, from a comparison of one object with another. We compare lengths, volumes, weights, colors, sounds, temperatures, and in short every property which will serve to distinguish two objects. If I wish to compare the lengths of two rivers, I cannot move the rivers side by side for comparison and so I compare each river with the length of a certain chain and draw my conclusion. But whether the comparison is direct or indirect, its nature is the same. No conclusion can be drawn where there is no common basis of comparison, where no common measuring stick exists. Thus no conclusion can be drawn from the comparison of a red light and a certain note of music.

The value of the comparison depends on the correctness of the conclusion drawn when the two objects are compared, and the correctness of the conclusion depends upon two things—the comparison and the mind. You must make the comparison carefully and you must trust the testimony of your mind as to the existence of the likeness or difference. I wish to emphasize the fact, that when the comparison has been carefully made, you are obliged to trust the testimony of your mind as to the existence of a likeness or difference. If you cannot trust your mind to give you a true conclusion when the facts are accurately presented you cannot do business as a scientist or as a thinker.

*The third point* to which I wish to call your attention is the fact that the human mind holds certain beliefs with a tenacity which nothing can shake. Thus if I make the statement that "Two straight lines cannot enclose a space", you will agree that it is true. More than this you will agree that it is true of all straight lines. And you will agree immediately, and without argument, and with just as great a feeling of certainty after the first instant of thought as you will ever subsequently possess. Thinking about the matter, or seeing other straight lines, does not increase the first feeling of certainty which you had. Similarly you will agree at once that "Through a given point only one line can be drawn parallel to another given straight line". Also you will agree that "Nothing can both be and not be". You will agree that the "Whole is always greater than any one of its parts", and also that "The sums of equals are equal". Such statements are called axioms. Euclid called them κοιναὶ ἔννοιαί, or "common notions", and that is, perhaps, a better name.

Now why are we so certain of the truth of these and similar statements or axioms? Or as Sir J. S. Mill put the query "Why is a single instance, in some cases, sufficient for a complete induction, while in others, myriads of concurring instances, without a single exception, known or presumed, go such a very little way towards establishing a universal proposition?" Some believe that this intuitive conviction of the truth of certain statements is simply in the nature of a necessary condition of our thinking faculty. Others that this intuitive knowledge is in the nature of a free gift with our minds. Others that even such truths are the result of experience. And yet others, recognizing that our conviction of the truth of these statements cannot be wholly the result of our own experience, would have us attribute our belief to the experience of our ancestors, and if we are evolutionists, we may trace our feeling back to the monkey and the primordial germ.

Those philosophers who contend that all of our knowledge is derived from experience really seem to have the best of the argument. For we know that most of our knowledge is derived from experience. As we make wider generalizations the laws seem to us to possess a greater certainty. What then is the advantage of resting even our most fundamental axioms on any other ground? Moreover inconceivability cannot be made a criterion of impossibility for man's ability to conceive of a thing of which he has had no suggestion is certainly very doubtful, if not admitted as an impossibility. And this fact alone, perhaps, explains our feeling of complete certainty when we give voice to fundamental axioms. If to all this Mr. Spencer's evolution theory of an inherited experience be added, there is an *a priori* conviction (feeling) that certain axioms are true so far as any particular individual is concerned. It is therefore impossible to dislodge by any argument these philosophers from their position.

On the other hand so far as the individual himself is concerned, it is certain, that there is a very great difference between the knowledge which he derives from his own direct experience, and the knowledge which he possesses apparently intuitively, and after all, it may be, that this intuitive knowledge is not the result of experience.

It is useless to follow the argument here. The scientist is not concerned primarily with the dispute as to the origin of these common notions which have been recognized and stated as axioms. From the standpoint of science the primary question is "Are these axioms true"? And if we say axioms are true then "What test can be adopted which will enable us to decide upon what an axiom really is?" We will define an axiom as *a statement whose truth our minds will not allow us to deny and of whose falsity our minds cannot even conceive.* If we accept the view of those who believe in an intuitive source of knowledge, then all axioms are equally true, and we must follow the intuition of our minds and accept those truths declared by our minds to be self-evident and impossible of contradiction. If on the other hand we agree with those men who think that all of our knowledge is derived from experience, or from the inherited experience of our ancestors, we cannot declare that any axioms are necessarily true. For accepting this point of view we must recollect that there may have been a mistake about the impressions all the way down the line from the primordial germ through the monkey to the man. And besides there may be experiences in store for us of a kind which it was not the good fortune of our ancestors to have had. Thus each axiom becomes separately a subject of doubt.

We would, however, point out that no matter what our view as to the origin of our belief in the axioms, to deny the truth of the axioms is to deny the testimony of our own consciousness. And we must believe in the truth of the testimony of our minds if we would reason at all. This we have already made clear. You cannot deny the testimony of your consciousness and yet continue to reason, for the belief that your mind will give you a true judgement when the facts are accurately presented before it constitutes the very foundation of the reasoning process. If you agree with this idea then follow me to its conclusion.

Can you conceive of motion without something moved ? Is not the idea of motion necessarily connected with the idea of a "something" that is moved? If your minds tell you that this idea is true, that it is necessarily true, and if you can not conceive of a contrary condition, then put this idea down as an axiom of science.

Again, can you conceive of a body acting where it is not across an absolutely empty intervening space? If you cannot, then let us put down as another axiom of science the fact, that a body cannot act where it is not, except through the intervention of another body.

Other axioms of science might be stated. For instance it might be stated that "The fundamental particle, or part, of matter can not be elastic". Many physicists would regard such a statement as beneath their notice. Yet it is nevertheless true that the property of elasticity implies a motion of certain portions of a body with reference to other portions of the same body, and so long as we have this relative motion of certain parts with reference to other parts we have not yet reached the final division limit of the body.

Personally I believe that the law of the conservation of matter and the law of the conservation of energy would both appear as axioms if we only understood more thoroughly the nature of matter and of energy. Likewise Newton's three laws of motion would doubtless appear to be axioms.

This morning I am not attempting to make a list of the axioms of science, nor shall I attempt here to trace out the consequences that would follow from those already mentioned. The consequences are, I may say in passing, I think, both important and surprising. I do wish to emphasize this morning that chemistry and physics have as much right to these axioms as a mathematician has to the axioms of geometry. They rest upon precisely the same ground. They are common notions in which we are compelled to believe by the testimony of our minds. Moreover I wish to emphasize that a clear statement of these fundamental axioms and principles, and a clear understanding of them, would prevent many absurdities which act continually as a drawback to a greater advancement. I will give some concrete illustrations of my meaning.

1. How often do we find a statement that such and such a thing has been proved as a result of a mathematical investigation. Now a mathematical investigation can obtain as a result absolutely nothing that was not contained in the premises. The result may be given in a vastly more digested and convenient form. But nothing which was not contained, openly or concealed, in the premises, can be obtained in the conclusion. You cannot get more out of a mathematical process than you put in.

2. An investigation is often damned unjustly by a reviewer as being theoretical merely because it contains mathematics. A paper may be largely of a mathematical character and yet be in no sense more theoretical than is many a simple laboratory measurement or research.

3. Note the most advanced theory of our atom as given by the most advanced physicist of the present time, Sir J. J. Thompson. "Our atom therefore, we assume to be a sphere of positive electrification enclosing a number of negatively electrified corpuscles." If you look upon that idea as an assumption made to enable one to treat mathematically two opposing forces capable of producing equilibrium I have no fault to find. But if you are led away to worship that idea with a species of ancestor worship as representing the skeleton forefather of the ordinary atom your conscience should trouble you whether it does or not. The idea of having a shell or sphere made of nothing so that we may not be unduly troubled with questions about it is ingenious we admit, but does your mind consent to believe it true?

4. It is a known fact that if you pass an electric current through a solution of copper sulphate the copper is given off at one electrode and the $SO_4$ at the other, and one atom of copper is liberated for each atom of $SO_4$ and both atoms are liberated at the same time. Now to explain a certain change that takes place in the concentration of the solution around the electrodes Prof. Ostwald has attempted to show that the ions of Cu and of $SO_4$ can move with *different velocities* across the *same space* and yet be *given off at the same time.* And that very ingenious "explanation" has been copied in nearly every physics, and physical-chemical, and electro-chemical text-book of the last ten years with a faith that passeth all understanding.

5. Another curious illustration of the absolute disregard of the testimony of our consciousness is the attempt to do away altogether with the idea of matter and to substitute energy as the kernel of all things. I cannot stop to discuss the reasons advanced for the change. I would only point out that whatever reasons may be advanced the position is an unsound one unless your mind can be made to give its consent. And neither your mind nor my mind can conceive of a world in which things do not occupy space.

I have a text-book on physical chemistry written by Prof. C. L. Speyers of Rutgers College in 1897 from this point of view. He tries hard to get along without the use of the terms, atom, molecule, and matter, I quote two paragraphs from his book:—

"In ordinary chemical language we say chemical reaction takes place between definite weights of matter. In our language we should say the relation between the intensities of the distance energies (gravity energies) of two or more collections reacting to form another definite collection is fixed.

When two substances combine in more than one proportion to form two or more bodies, in ordinary chemical language we should say the ratio of the varying substance to the fixed substance is in general more or less simple. In our language we should say when two collections are capable of uniting to form more than one new collection by their union, the ratio of the intensity of the gravity energy in the varying collection to the intensity of the gravity energy in the fixed collection is in general more or less simple."

The man is not crazy. He is simply carrying to an extreme just the same ideas possessed by a good many other leading chemists.

6. Less curious, but perhaps even further wrong than the idea just mentioned, is the idea that we can talk about energy scientifically without making any assumptions regarding its nature. Now it was early recognized by the Greek and Roman philosophers, and I understand that much of their thought probably came from a far earlier Eastern philosophy, that if we considered matter to exist it could be divided. These parts could be divided again, and so on, until the very interesting question was presented, When, if ever, would the possibility of division stop? Chemists recognize as steps in this division the molecule, the atom, and perhaps the corpuscle or electron. Now many scientists seem to possess the idea that no such question necessarily arises regarding energy? They say in effect, "We know nothing of the nature of energy and why therefore discuss its divisibility or indivisibility? We make no assumptions concerning it one way or the other". I would answer this fallacy by an illustration. If I say one-third of the people in a car were killed in a certain railroad wreck my statement seems all right perhaps, but if there were ten people in the car then my statement is seen to be absurd. If you make no assumption about the nature of energy then you cannot treat energy mathematically. Euclid overlooked a certain axiom concerning space which modern geometricians recognize as being necessary, namely, that "Space is continuous". Modern scientists should not overlook the assumptions made regarding energy. The continuity or the divisibility of energy is a problem exactly on a par with the problem as to the continuity or divisibility of matter?

7. Physicists and chemists do not stand alone in their attempts to thrust aside the testimony of their minds as to one concept, and to accept at the very same time the conclusions of the very same mind regarding other things. Thus there are a good many mathematicians who speak of the possibility of a space of "n" dimensions. Now we can conceive of a point, of a line, of a surface, and of a solid. And we understand quite readily that one unknown quantity might be used to fix the position of a point on a line, that two might be used to define or to represent points on a plane surface, and that similarly three would serve to indicate

the points in a solid. We understand quite as readily that an equation with four unknown quantities, or with five unknown quantities, can be constructed, and that this equation would likewise represent certain relations between the unknown quantities. But to declare that this equation also might represent space is as meaningless as it would be to declare that it represents time. Such a declaration is certainly contrary to the testimony of the very same mind that we have used as our guide in the mathematical reasoning, and to accept its conclusions at one point and reject them at another is an entirely indefensible position.

8. Non-Euclidean geometry is an illustration of the same method of proceedure. Gauss undertook to investigate mathematically the properties which a surface must possess in order to permit figures to be moved about upon the surface without altering the shape or the size of the figures. He found that there were three classes of such surfaces. A plane surface, the surface of a sphere and the surface of a figure which became known as the pseudo-sphere. Lobatchewsky, a pupil of Gauss, undertook a similar investigation regarding space. What properties must space possess in order that bodies could be moved about in the space from one part of the space to another without altering the shape or the size of the bodies? He found similarly three classes of equations, one representing the ordinary Euclidean, or plane space, the others corresponding to the sphere and the pseudo-sphere of the investigation carried on by Gauss. Many wonderful results followed from these investigations and I am not intending to detract from the value of that work, or of similar work. But one of the results arrived at was, that in "plane" space only, was the following axiom true:—"Through a given point only one straight line can be drawn parallel to a given straight line." In both the "spherical" and the "pseudo-spherical" space this axiom was untrue. Now I do not question the correctness of the work or of the equations. But I do question that we have a right, because of them, to cast aside the unmistakably clear belief in the above axiom forced upon us by our minds. Whatever the other equations may represent, or whatever their meaning, we have no right to violate the testimony of the mind that derived them, and declare that they represent space.

I have not time this morning to give further illustrations of my statement that the lack of knowledge of the first principles of science, as shown by scientists, is the cause of much needless confusion. If I were to point out individual errors due to this cause that have come to my attention I would occupy the entire day. These errors are caused, not by any failure of our minds to give us a true judgement, but by our own failure to read carefully the answer which our mind has given. If in the last analysis the testimony of consciousness cannot be trusted we had just as well give up the search for truth. We cannot hope to attain to any absolute knowledge or full conception of any of the more elementary ideas such as time, space, matter, motion, or energy. But we may attain to a partial knowledge of these ideas and this partial knowledge, we trust, may represent the reality truly, so far as it represents it at all. And in attempting to attain this partial knowledge, if one goes directly contrary to the testimony of one's mind as to the possibility or impossibility of a conception, one should not forget that the process of denying the truth of the testimony of consciousness once begun, can be as legitimately extended to an absolute agnosticism. Must be so extended, if one is consistent. If a scientist should wish to introduce into his science an idea which is contrary to the conception of things imposed upon him by his mind, let him do so. But he should himself understand, and he should make clear to others, that he has not only contradicted one particular "necessary concept" of his mind, but that *in so doing he has inaugurated a process which could consistently be extended so as to undermine his whole structure.* A scientist may state that matter may be but a center of force, and we have no fault to find. But he has no right, in the next breath, to swear by the result of a mathematical investigation which involves axioms resting upon the same ground as the one that he has just contradicted. If greater attention were given to the foundations of science doubtless some phenomena would remain "unexplained" but some very confusing ideas would be banished from the domain of science.

In conclusion I would ask those who are here today, if your mind has agreed with the ideas presented, to endeavor so far as it may be in your power, to bring about among chemists a clearer recognition of the service which a discussion of the first principles of science would render to chemistry. The attitude of chemists and of other scientists, is today so pronounced in opposition to such discussion that it is exceedingly rare to find a text-book which even alludes to the subject. Nowhere today, does a scientific student, who has not read or studied philosophy as well, obtain an idea of the basis of thought, or of mathematics, or even of science itself. Disagree with me you may concerning some of the particular statements that I have made this morning. But your very disagreement itself speaks in favor of a discussion of these first principles in order that we may the sooner clear away the misunderstandings which exist. At present one can hardly attempt their discussion without losing in some measure the respect of his fellow scientists. My brethren these things ought not so to be.

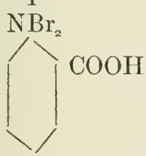
CHAPEL HILL, N. C.

# 5-BROM-2-AMINOBENZOIC ACID, A NEW PREPARATION

ALVIN S. WHEELER

The original object of this investigation was to convert trichlorethylidene-o-aminobenzoic acid[1] into a compound containing an asymmetric carbon atom by means of bromine or hydrobromic acid, thus $CCl_3CH:NC_6H_4COOH = CCl_3CHBrNBrC_6H_4COOH$. A glacial acetic acid solution of the unsaturated compound absorbs bromine instantly in the cold with the immediate formation of a white precipitate. A Carius determination showed a marked deficiency of halogen and displacement of the bromine in the silver precipitate proved the entire absence of chlorine in the substance. Further proof that the chloral residue was split off was found in an examination of of the acetic acid filtrate. This was made alkaline, then acid with tartaric acid and distilled in steam. A large quantity of chloroform passed over with steam. The product was therefore a simpler derivative of anthranilic acid than the one looked for. Since the break occurs at the double bond, it might be a nitrogen bromide I or II, or the hydrobromide of a bromanthranilic acid III.

I

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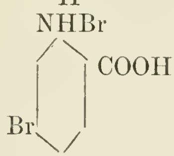
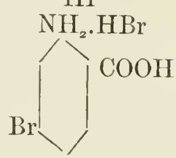



III




Difficulty was experienced in obtaining products of the same melting point, different solvents giving slightly varying results. While none of the reactions of the nitrogen halides as indicated by Chattaway and Orton[2] could be obtained, it was thought this

[1] Niementowski and Orzechowski, Ber. 28,2812; also Wheeler, Jr. Am. Chem. Soc. 30,139.

[2] Chattaway and Orton, J. Chem. Soc. 75,1046.

might be due to the insolubility of the compound. But the idea of a nitrogen bromide was abandoned when it was observed that cold water immediately and completely removed one molecule of hydrobromic acid, showing the substance to be the salt of bromaminobenzoic acid. It is still hoped to isolate in some way the nitrogen bromide which must certainly be the first product of the reaction. The case is an especially interesting one because it is quite unique in that the substance employed contains the grouping -N=X and so seems to offer an unusually good chance to form a nitrogen halide.

It was next observed that direct bromination of anthranilic acid in glacial acetic acid solution gave a similarly large yield of the bromaminobenzoic acid hydrobromide. The reaction therefore offers a new method of preparing this acid far superior in point of time and convenience to the method of Alt[1] which has been recently used by Bogert and Hand.[2] This old method consists in brominating o-acettoluide, oxidizing the brom-o-acettoluide with permanganate and saponifying the bromacetanthranilic acid. The method requires as many days as this new method requires hours. A comparison of the bromination of the chloral-anthranilic acid and of anthranilic acid shows that the chloral residue has some influence on the course of the reaction.

*Bromination of chloral-anthranilic acid. 5-Brom-2-aminobenzoic acid hydrobromide*, $C_6H_3COOHBrNH_2.HBr$. A saturated solution of chloral-anthranilic acid (m. 152°) was made by dissolving 13.3 grams in 100 cc glacial acetic acid by warming and then cooling nearly to the room temperature. Bromine, 8 grams, was added drop by drop with stirring. Crystals began to form before half of the bromine was added. Finally a very thick pulp was obtained, the temperature having risen to about 45.° The proportions of the materials were 1 molecule of acid and 2 atoms of bromine. The precipitate was filtered off and washed several times with benzene. The compound so obtained is snow white and nearly pure. It gives a melting point of 238-40°, decomposing and becoming

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1 Alt, Ber. 22, 1645, (1889).

2 Bogert and Hand, Jr. Amer. Chem. Soc. 27,1476 (1905).

an indigo blue liquid immediately above this temperature. The yield was equal to the weight of the chloral-anthranilic acid used or 91 per cent of the theoretical. Analysis: calculated for $C_7H_7O_2NBr_2$, Br 53.86, found, Br 53.40, 54.16, 53.45.

The hydrobromide is broken down at once by cold water into the free amine and hydrobromic acid which accounts for difficulties arising in recrystallizing from solvents not especially dried. It is insoluble in ether, benzene, ligroin, carbon tetrachloride and chloroform, slightly soluble when these solvents are hot. It is insoluble in cold glacial acetic acid but soluble in about 150 parts when boiling, separating out in needles. It is rather soluble in cold absolute alcohol, soluble in 6 parts when boiling, crystallizing out in needles grouped in rosettes.

*5-Brom-2-aminobenzoic acid.* $C_6H_3COOHBrNH_2$. Although the acid is set free from its hydrobromide by cold water, hot water was used in order to effect a recrystallization of the acid simultaneously. The acid was found to agree in all its properties with the acid as described by Alt and later by Bogert and Hand except in one particular. Alt gives the melting point as 211–211.5° (uncor) while Bogert and Hand give 219–220° (cor.). Our acid melts at 215–216° (uncor) or 218–219° (cor), in practical agreement with Bogert and Hand. We have observed further that a partial decomposition takes place. As Alt has stated an aqueous solution of the acid turns violet in the sunlight and a solution of its ammonium salt gives colored precipitates with certain other salts. Its acetyl derivative consists of splendid prisms, melting at 218–220°. Alt gives 214–215°. Analysis: calculated for $C_9H_8O_3NBr$, Br 31.01: found, Br 31.62. The position of the bromine atom was positively located by conversion of the acid into m-brombenzoic acid by the diazo reaction.

*Bromination of Chloral-di-anthranilic Acid.* This acid is described by Niementowski[1] and by Wheeler and Dickson[2]. 2.0 grams of chloral-di-anthranilic acid (1 mol) were dissolved in 30 cc glacial acetic acid and treated with 1.6 grams (2 mols) bro-

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1 Niementowski, Ber. 34,3898 (1902).

2 Wheeler aud Dickson, this Journal, 30,140 (1908).

mine. The abundant white precipitate was worked up as in the previous case. The yield was 2.7 grams or 91.5 per cent of the theoretical. The melting point was 238-239° with decomposition to an indigo blue liquid. Cold water removed one molecule of hydrobromic acid. The residue was recrystallized from water, forming needles melting at 215-216° with partial decomposition. The reaction is therefore identical with bromination of chloral-mono-anthranilic acid.

*Rapid Preparation of 5-Brom-2-aminobenzoic Acid. First Method, with Use of Chloral.* Since it is immaterial whether the chloral-mono-anthranilic acid or the chloral-di-anthranilic acid is used in the bromination, the products of the action of chloral upon anthranilic acid need not be separated. 25 grams of anthranilic acid are rubbed up in a mortar to a powder, 27.5 grams of chloral are added and the mixture is rapidly triturated a few minutes. The mass partially liquifies with the development of heat and then becomes quite hard. It is at once dissolved in 350 cc glacial acetic acid by warming and then cooled to 16°. Bromine, 29.4 grams, is added slowly enough to keep the temperature from rising above 16°, the beaker being surrounded by cold water. The precipitate is filtered off and washed with benzene. It melts at 239-240° and weighs 51 grams or 94 per cent of the theoretical. Its conversion into the free acid and its purification were effected as follows. 5 grams of the hydrobromide were boiled up in 250 cc water three times, filtering hot with suction into a flask standing in boiling water. The filtrates were cooled by surrounding with ice water and then filtered. Extract I, m. 215-216°, weight 1.35 gram; extract II, m. 215-216°, weight, 0.95 gram; extract III, m. 208-210,° weight, 0.35 gram. Insoluble residue none. By adding 3 volumes of water to the glacial acetic acid filtrate, a precipitate was obtained, melting at 185-200° and weighing 0.3 gram. Analysis of this product showed it to be a tribromamino-benzoic acid. The bromine (29.4 g) is accounted for as follows: 2 g lost in the original preparation, 14.7 g are lost as HBr, 10.4 g appear in the 5-brom-2-aminobenzoic acid, 1.9 g appear in the tribromaminobenzoic acid. The balance, 1.4 g, disappear in the mother liquors. Recrystallization of extract I from toluene effected no rise in melting point. In some preparations the first extracts were not quite so pure and one recrystallization from toluene was necessary. At no time was boneblack necessary as in the old method. Analysis: calculated for $C_7H_6O_2NBr$, Br 37.04; found, Br 37.39.

*Second Method. Direct Bromination of Anthranilic Acid.* (With W. M. Oates.) 25 grams anthranilic acid were dissolved in 250 cc glacial acetic acid and cooled to 15-16°. Bromine, 29.4 grams, was added slowly enough to keep the temperature from rising. Further procedure was the same as described above. The product melted at 236-238° and weighed 51.5 grams which is 95.3 per cent of the theoretical. Conversion and purification were carried out as already described. 5 grams of the hydrobromide gave the following results: extract I, m. 212-214°, weight, 1.4 g; extract II, m. 212-214°, weight, 0.8 g; extract III, m. 203-205°, weight, 0.3 g; extract IV, m. 226-232,° weight, 0.1 g. Undissolved residue, m. 228-230°, weight, 0.4 g. The first extract was recrystallized from toluene and analyzed. Analysis: calculated for $C_7H_6O_2NBr$, Br 37.04; found, Br 37.44, 37.65. The undissolved residue, m. 228-230°, was also analyzed. Analysis: calculated for $C_7H_5O_2NBr_2$, Br 54.24; found, Br 52.18. It was therefore a dibrom derivative of anthranilic acid. The bromine, 29.4 grams, is accounted for as follows: 1.7 g lost in the original preparation; 13.8 g lost as HBr, 9.5 g appear in the 5-brom-2-aminobenzoic acid; 2.8 g appear in the dibrom anthranilic acid and the balance, 1.6 g, are lost in the mother liquors. The acetic acid filtrate in this method of preparation did not yield any precipitate on the addition of water. A comparison of results in the two methods is as follows:

| I | II |
|---|---|
| Mainly 5-brom-2-aminobenzoic acid | Similar amount |
| Small amount tribrom acid | No tribrom acid |
| No dibrom acid | Small amount dibrom acid |

*m-Brombenzoic Acid.* This acid was prepared in order to locate positively the bromine atom in the bromaminobenzoic acid described in this paper. It proved to be a convenient method of preparation because the product is so quickly purified, which can not be said of the product of the action of bromine on benzoic acid. 5.0 grams 5-brom-2-aminobenzoic acid were dissoved in 50 cc absolute alcohol. After the addition of 5 g $H_2SO_4$, con., the solution was brought to boiling and 2.5 g $NaNO_2$ dissolved in a very little water were added. The solution was filtered from the sodium sulphate and added to a large volume of water. The pinkish colored precipitate was filtered off and dried. It showed a melting point of 145-147° and weighed 3.82 g or 82 per cent of the theoretical. On recrystallizing from boiling water a very small amount of a dark red substance was gotten rid of and the m-brombenzoic acid was obtained in pure condition, m. 154°. Analysis: calculated for $C_7H_5O_2Br$, Br 39.80; found, Br 39.37.

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# RAPID DETERMINATION OF OIL IN COTTONSEED PRODUCTS*

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Received November 10, 1908.

In the manufacture of cottonseed oil the delinted seeds are cut and the meats or kernels separated mechanically from the hulls. The meats are then mashed between heavy rollers, cooked in steam-jacketed vessels, and the oil expressed by hydraulic pressure. The determination of oil in the hulls gives a measure of the completeness of the separation of the meats from the hulls, while the oil content of the meal affords a control of the character of the press work. It would seem, therefore, that a prompt and constant knowledge of the oil content of the hulls and meal would be indispensable in the operation of a mill. However desirable, this is by no means the case in actual practice. Two explanations suggest themselves: first, the organization of the industry; second, the method of analysis employed. The erection of many small mills is made necessary by the bulky character of the cottonseed, with its consequent cost of transportation, and by the impossibility of storing large quantities of seed for any great length of time without marked deterioration. The output of many of these small mills is not sufficient to justify the employment of a trained chemist, and the time required for obtaining an analysis from a distant laboratory largely discounts the value of the knowledge gained, except in extreme cases. But even if a laboratory is close at hand, or in the mill itself, five or six hours must elapse before the result of the analysis reaches the mill from the laboratory, this on account of the method of analysis employed. A more general resort to chemical control could be

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expected, therefore, if a simple and rapid method of analysis were available. The present investigation has been undertaken in the hope of filling this need. Furthermore, the purchase of cottonseed by the mills is conducted regardless of the oil content of the seed. It is hoped that the rapid method here described may be of some service in this important matter.

### OBJECTIONS TO PRESENT METHOD

The method of analysis usually employed consists in extracting the oil from a sample in a Soxhlet extractor with redistilled, low-boiling petroleum ether, evaporating the extractive and weighing the residual oil.

The objections to the method are:

First, the extraction must be conducted at a relatively low temperature, this being determined by the temperature of the condensed extractive dropping upon the sample from the condenser above.

Second, in the Soxhlet apparatus it is necessary not only to completely extract the oil but to transfer it completely to the flask below by repeated siphonings.

Third, considerable time is consumed in the complete evaporation of the extractive.

Fourth, the limitation to a comparatively small sample of the substance.

Fifth, the danger from fire.

Sixth, the necessity of using rather expensive apparatus and the need of a supply of running water for the condensers.

Seventh, the necessity of employing a trained chemist to conduct the operations.

### PROPOSED METHOD

It is believed that all of these objections are met in the method here proposed. It consists in digesting a definite and relatively large quantity of the substance with a definite volume of carbon tetrachloride in a loosely stoppered Erlenmeyer flask for 15 minutes at a temperature of approximately 60° C., cooling to room temperature, shaking thoroughly, filtering and determining the specific gravity and temperature of the filtered extract. From these observations the per cent. of oil is calculated. Detailed directions for the analysis of the several products follow:

*Meal.*—Forty grams of the thoroughly mixed sample of meal are transferred to a 250 cc. Erlenmeyer flask, which is then placed in a water bath previously heated to approximately 60° C. After heating the flask about 2 minutes 100 cc. of carbon tetrachloride are poured gently upon the meal through a funnel reaching almost to the surface of the meal. The flask is lowered in the water until the surface of the carbon tetrachloride is lower than that of the water, a cork loosely inserted and the extraction allowed to proceed. Slight variations in the temperature of the water bath do not affect the accuracy of the determination. The minimum time for the extraction is 15 minutes, it may be longer. When the extraction is completed the flask is cooled to room temperature, thoroughly shaken and the contents strained through wire gauze on to a folded filter, the gauze being squeezed to insure sufficient filtrate. The clear extract is caught in a specific gravity tube (5 inches by 1 inch test-tube on foot). This is filled to within one inch of the top, then tightly corked and placed in a vessel containing water at room temperature. After standing at least 10 minutes the tube containing the extract is placed in a 500 cc. plain beaker containing sufficient clear water, at room temperature, to reach the level of the extract in the tube. By this means too rapid change in the temperature of the extract is avoided. The cork is then removed, the specific gravity of the extract determined by the Westphal balance, and the temperature accurately noted from the thermometer placed within the plummet of the balance. Add or subtract the constant for the carbon tetrachloride in use and subtract the corrected specific gravity of the extract from that of the carbon tetrachloride shown in Table 6 at the same temperature. This difference is divided by 0.00286. The result is the per cent. of oil.

*Hulls.*—After removing whole seed from the sample of hulls, 40 grams are placed in an Erlenmeyer flask and slightly packed with a glass rod. This is necessary to insure complete covering of the bulky hulls by the extractive. 100 cc. of carbon tetrachloride are added. The rest of the determination is identical with that for meal, except that the gauze strainer is not necessary in filtering.

*Meats.* The method is the same as for meal except that 10 grams of meats are used with 100 cc. of carbon tetrachloride. The per cent. of oil found is multiplied by four.

*Seed.*—The sample of seed is thoroughly pounded in an iron mortar and the mass passed through a meat chopper. Forty grams are used with 200 cc. of carbon tetrachloride. The method is the same as for meal except that the per cent. of oil found is multiplied by two.

## Experimental

### THE EXTRACTION

The well known solvent power of carbon tetrachloride for fats, its relatively high boiling point, its low heat of vaporization and its non-combustibility, naturally suggested this substance as a substitute for gasoline and ether as the extractive. A P. Bryant,[1] using a Knorr extractor, demonstrated the rapidity of extraction of fats in foods and feedstuffs by carbon tetrachloride. But he proposed merely the substitution of carbon tetrachloride for ether or carbon bisulphide in the usual method of extraction and evaporation of the extractive.

In the following experiments the determinations were carried out as follows: five grams of a substance whose oil content had been determined by the Soxhlet method were transferred to a 500 cc. Erlenmeyer flask, 50 cc. of gasoline or carbon tetrachloride added, and the extraction allowed to proceed at room temperature and without shaking, in order to avoid the sticking of the solid particles to the walls of the flask above the extractive. After standing a definite time the flask was thoroughly shaken in order to insure uniformity of the extract. This was then filtered through a dry filter paper. The amount of dissolved oil was determined in 25 cc. of the filtrate by distilling off the extract in a hot air bath, the temperature being quickly raised to 140° C. during the last stages of the evaporation. The last traces of the extractive were removed from the distillation flask by blowing quickly into it through a glass tube inserted almost to the oily layer. From the weight of the oil the per cent. was calculated by multi-

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1 *J. Am. Chem. Soc.*, 26, 568.

plying by one hundred and dividing the product by two and a half.

*Cottonseed Meal.*—7.29 per cent. oil by Soxhlet extraction with gasoline.

TABLE 1

| Time of extraction. | Per cent. oil with gasoline. | Per cent. oil with carbon tetrachloride. |
|---|---|---|
| 7½ minutes | 6.72 | 2.84 |
| 15 " | 7.32 | 7.10 |
| 30 " | 7.34 | 7.22 |
| 60 " | 7.28 | 7.30 |
| 120 " | 7.32 | 7.46 |

To determine the influence of temperature upon the rate of extraction by carbon tetrachloride, a series of experiments was carried out as above except that the Erlenmeyer flasks were placed in a water bath heated to 50° C. The results follow:

TABLE 2

| Time | Per cent. of oil. |
|---|---|
| 3¾ minutes | 7.08 |
| 7½ " | 7.44 |
| 15 " | 7.38 |

The marked increase in the extraction at 50° in 7½ minutes as compared with that at room temperature for the same time led to the hope that the time for complete extraction could be still further diminished by carrying out the determination near the boiling out the determination near the boiling point of carbon tetrachloride. This hope was fully justified, for by making an extraction at 70° for 3¾ minutes, the percentage of oil was found to be 7.30.

*Cottonseed Meats.*—30.27 per cent. oil by Soxhlet extraction.

TABLE 3

| Time. | Temperature. | Per cent. of oil. |
|---|---|---|
| 30 minutes | 25° | 29.22 |
| 30 " | 35° | 29.50 |
| 30 " | 50° | 30.38 |
| 30 " | 70° | 30.62 |

From these determinations it is evident that the time-consuming extraction with the Soxhlet apparatus is unnecessary and that an accurate determination of the oil in these products can be made with simple apparatus, in a much shorter time and with no danger from fire.

### RAPID DETERMINATION OF OIL IN EXTRACT

In order to simplify and hasten the determination of oil in the extract experiments were begun on the lowering of the specific gravity of the carbon tetrachloride by the dissolved oil. The great difference in the specific gravity of carbon tetrachloride (1.62) and of cottonseed oil (0.92) gave a reasonable hope of success. In order to avoid possible difference in the specific gravity of the crude oil obtained from the presses and that left in the meal the experiments were carried out on the samples of meal whose oil content was determined in the usual manner by the Soxhlet extractor. The simplicity of the Westphal balance suggested this method of determining the specific gravity. Comparison of the thermemeter on the plummet of the balance used in the investigation with a standard thermometer showed it to be accurate between 15° and 30°.

A preliminary test, using 5 grams of meal and 50 cc. of carbon tetrachloride, as in the above experiments on the rate of extraction, showed that the method would probably be accurate to 1 per cent. The first step, therefore, was to determine the minimum time and temperature for extractions of larger proportions of meal, the volume of carbon tetrachloride being kept constant. A sample of cottonseed meal was passed through a 20-mesh sieve, and thoroughly mixed. In two portions of ten grams each the oil was determined by the Soxhlet method, using redistilled gasoline as the extractive in one case and chemically pure carbon tetrachloride in the other. With the former the percentage was found to be 8.68; with the latter 8.67.

With this meal extractions were made according to the method outlined above. In each case allowance was made for the constantly increasing volume of oil in the extract. The results follow:

TABLE 4

| No. | Grams of meal. | cc. of carbon tetrachloride. | Time (minutes). | Temperature. | Per cent. of oil I | II |
|---|---|---|---|---|---|---|
| 1 | 10 | 50 | 5 | 70° | 8.67 | ... |
| 2 | 15 | 50 | 5 | 70° | 8.58 | ... |
| 3 | 20 | 50 | 5 | 70° | 8.60 | 8.63 |
| 4 | 25 | 50 | 5 | 70° | 8.18 | ... |
| 5 | 30 | 50 | 5 | 70° | 8.56 | ... |

From the per cent. found in No. 5 it is evident that the low result in No. 4 was due to analytical error.

The use of 30 or even 25 grams of meal was found to be impracticable, as it was found to be impossible to secure sufficient filtrate for use with the Westphal balance. But with 20 grams sufficient filtrate could be obtained by using a strainer of brass or iron gauze and squeezing the extract on to a crimped filter. In order to avoid possible error in the specific gravity determinations due to the small amount of filtrate the proportions were increased to 30 grams of meal and 75 cc. of carbon tetrachloride. For the specific gravity determination a test-tube-on-foot 5 inches long and 1 inch in diameter was used. A magnifying glass was used in reading the thermometer on the plummet of the balance.

TABLE 5

SPECIFIC GRAVITY OF CARBON TETRACHLORIDE.

| Temperature. | Specific gravity. |
|---|---|
| 15° | 1.6041 |
| 20° | 1.5951 |
| 25° | 1.5861 |
| 30° | 1.5771 |

Since these figures show a regular variation of 0.0090 for each 5 degrees the figures for intermediate temperatures are interpolated as follows:

TABLE 6

| Temperature. | Sp. gr. | Temperature. | Sp. gr. | Temperature. | Sp. gr. |
|---|---|---|---|---|---|
| 15.0° | 1.6041 | 17.2° | 1.6001 | 19.4° | 962 |
| .2° | 037 | .4° | 1.5998 | .6° | 958 |
| .4° | 034 | .6° | 994 | .8° | 955 |
| .6° | 030 | .8° | 991 | 20.0° | 951 |
| .8° | 027 | 18.0° | 987 | .2° | 947 |
| 16.0° | 023 | .2° | 983 | .4° | 944 |
| .2° | 019 | .4° | 980 | .6° | 940 |
| .4° | 016 | .6° | 976 | .8° | 937 |
| .6° | 012 | .8° | 973 | 21.0° | 933 |
| .8° | 009 | 19.0° | 969 | .2° | 929 |
| 17.0° | 005 | .2° | 965 | .4° | 926 |

| | | | | | |
|---|---|---|---|---|---|
| 21.6° | 922 | 24.4° | 872 | 27.2° | 821 |
| .8° | 919 | .6° | 868 | .4° | 818 |
| 22.0° | 915 | .8° | 865 | .6° | 814 |
| .2° | 911 | 25.0° | 861 | .8° | 811 |
| .4° | 908 | .2° | 857 | 28.0° | 807 |
| .6° | 904 | .4° | 854 | .2° | 803 |
| .8° | 901 | .6° | 850 | .4° | 800 |
| 23.0° | 897 | .8° | 847 | .6° | 796 |
| .2° | 893 | 26.0° | 843 | .8° | 793 |
| .4° | 890 | .2° | 839 | 29.0° | 789 |
| .6° | 886 | .4° | 836 | .2° | 785 |
| .8° | 883 | .6° | 832 | .4° | 782 |
| 24.0° | 879 | .8° | 829 | .6° | 778 |
| .2° | 875 | 27.0° | 825 | .8° | 1.5775 |

*Meal.*—To determine the lowering of the specific gravity of the carbon tetrachloride by increasing quantities of extracted oil a meal of known oil content (8.82 per cent.) was used. Quantities of this meal were used representing 30-gram portions each of 5.0, 7.5, and 10.0 per cent meals; thus for

5.0 per cent. used 17.0068 grams;
7.5 per cent. used 15.5102 grams;
10.0 per cent. used 34.0135 grams.

These portions were extracted, each with 75 cc. of carbon tetrachloride in Erlenmeyer flasks for 5 minutes at 70°. The filtered extracts showed the following specific gravities:

TABLE 7

| Temperatures. | 5 per cent. | 7.5 per cent. | 10 per cent. |
|---|---|---|---|
| 15° | 1.5900 | 1.5830 | 1.5758 |
| 20° | 1.5810 | 1.5740 | 1.5668 |
| 25° | 1.5720 | 1.5650 | 1.5578 |

The same difference in specific gravity of 0.0018 for each degree of temperature is observed here as was found with the carbon tetrachloride alone, but the decrease in specific gravity due to the increasing quantities of oil is not quite so regular. Thus the decrease due to the oil in 30 grams of a 5 per cent. meal is 0.0141, but in a 10 per cent. meal 0.0283. To test this more carefully a new and more delicate Westphal balance was obtained. The meal used contained 8.20 per cent. of oil. Quantities of this meal were used, representing 40 gram portions each of 5 and 10 per cent. meals, the volume of carbon tetrachloride being increased accordingly to 100 cc. In order to avoid too rapid change in the temperature of the extract during the determination of the specific gravity, the tube containing the extract was placed in a 600 cc. plain beaker filled with clear water to the level of the extract. Different specimens of carbon tetrachloride were used in the two sets of experiments. Corrections for temperature were made on the basis of 1°=0.0018 difference in specific gravity.

TABLE 8

FIVE PER CENT MEAL.

SPECIFIC GRAVITY OF CARBON TETRACHLORIDE AT 26.4°=1.5866.

| Extract | Temperature. | Specific gravity. | Calculated to 26.4°. | Difference. |
|---|---|---|---|---|
| No. 1 | 26.7° | 1.5718 | 1.5723 | 0.0143 |
| No. 2 | 26.8° | 1.5716 | 1.5723 | 0.0143 |

TEN PER CENT MEAL.

SPECIFIC GRAVITY OF CARBON TETRACHLORIDE AT 24°=1.5918

| Extract | Temperature. | Specific gravity. | Calculated to 24° | Difference. |
|---|---|---|---|---|
| No. 1 | 24.0° | 1.5632 | 1.5632 | 0.0286 |
| No. 2 | 24.2° | 1.5628 | 1.5632 | 0.0286 |

The decrease in specific gravity is, therefore, regular and each per cent. of oil lowers the specific gravity 0.00286 when 40 grams of meal and 100 cc. of carbon tetrachloride are used. The per cent. of oil in a meal is obtained, therefore, by determining at the same temperature the difference between the specific gravity of the carbon tetrachloride and the filtered extract from 40 grams of the meal digested with 100 cc. of the carbon tetrachloride and dividing this difference by 0.00286.

CONSTANT FOR CARBON TETRACHLORIDE.

The difficulty in securing different lots of commercial carbon tetrachloride of exactly the same specific gravity led to experiments with a grade differing widely from that used in the earlier part of the investigation. The following results were obtained:

TABLE 9

| Temperature. | Sp. gr. original carbon tetrachloride. | Sp. gr. new carbon tetrachloride. | Difference. |
|---|---|---|---|
| 15° | 1.6041 | 1.5903 | 0.0138 |
| 20° | 1.5951 | 1.5813 | 0.0138 |
| 25° | 1.5861 | 1.5723 | 0.0138 |

Having determined this difference, 0.0138, in all operations with this new lot corrections should be made by adding the constant to the observed specific gravity and immediate reference could be made to the table of specific gravity of the original carbon tetrachloride. Such a procedure would obviate the necessity of using a thermostat. To test this, 40 grams of meal containing 8.50 per cent. of oil were digested with 100 cc. of the new lot of carbon tetrachloride for 5 minutes at 70°. The extract showed a specific gravity of 1.5572 at 20°; adding the constant 0.0138 this becomes 1.5710, a difference of 0.0241 from the original carbon tetrachloride. Dividing by 0.00286 the per cent. was found to be 8.43.

TIME AND TEMPERATURE EXPERIMENTS.

Some specimens of commercial carbon tetrachloride boil at lower temperatures than that of pure carbon tetrachloride (76.7°). It was deemed advisable, therefore, to determine the rate and completeness of extraction at lower temperatures. In the determinations the per cents. were obtained by the specific gravity method, using a meal whose oil content had previously been found to be 8.82 per cent. The results follow:

TABLE 10

| Temperature. | 5 min. | 10 min. | 15 min. | 20 min. | 30 min. | Standing over night. |
|---|---|---|---|---|---|---|
| 25° | 7.32 | 7.50 | 7.32 | 7.50 | 8.00 | 8.16<br>8.19 |
| *25° | 7.50 | . . . | 8.00<br>7.81 | .. | 7.93 | .. |
| 40° | 7.72 | 7.72 | 7.88 | .. | .. | .. |
| 50° | 7.72 | 8.35 | 8.72 | .. | .. | .. |
| 60° | 8.06 | 8.06 | 8.75 | .. | .. | .. |
| | 8.08 | 8.06 | 8.81 | .. | .. | .. |

From this table it is evidently impracticable to work at room

*Shaking at intervals.

temperatures. The results show, however, that a complete extraction is obtained in 15 minutes at temperatures 50°–60° C. At such temperatures there is no risk of the commercial carbon tetrachloride boiling.

Confirmation of the accuracy of the method for cottonseed meal is furnished by the following check analyses, for many of which we are indebted to Mr. Jas. B. Pratt, chemist of the Southern Cotton Oil Co., Charlotte, N. C., and Mr. O. L. Spurlin, chemist of the Georgia Cotton Oil Co., Atlanta, Ga.

TABLE 11

| No. | Soxhlet extraction. | Specific gravity method. I. | Specific gravity method. II. |
|---|---|---|---|
| 1 | 8.81 | 8.72 | .. |
| 2 | 6.47 | 6.44 | .. |
| 3 | 6.49 | 6.59 | 6.56 |
| 4 | 7.17 | 7.25 | 7.27 |
| 5 | 6.47 | 6.47 | .. |
| 6 | 7.17 | 7.22 | 7.28 |
| 7 | 7.13 | 7.19 | 7.11 |
| 8 | 6.69 | 6.78 | 6.69 |
| 9 | 6.27 | 6.31 | 6.22 |
| 10 | 6.47 | 6.56 | .. |
| 11 | 7.17 | 7.06 | .. |
| 12 | 6.27 | 6.35 | 6.34 |
| 13 | 7.13 | 7.06 | .. |
| 14 | 6.69 | 6.59 | .. |
| 15 | 7.20 | 7.17 | 7.23 |
| 16 | 6.70 | 6.71 | .. |
| 17 | 5.96 | 5.94 | .. |
| 18 | 6.40 | 6.43 | .. |

*Meats*—Since the per cent. of oil in meats is high and varies between approximately 28 and 36 per cent., it was decided to use 10 grams of meats, instead of 40 as in the case of meal, with 100 cc. of carbon tetrachloride, in order to bring the specific gravity within the limit already worked out for meal, multiplying the per cent. found by four for the actual per cent. of oil in the meats. The use of a wire gauze strainer was unnecessary with meats.

TABLE 12

PER CENT. OF OIL IN UNCOOKED MEATS.

| Temperature. | Time. | I. | II. |
|---|---|---|---|
| 70° | 5 | 27.12 | 27.40 |
| 70° | 15 | 29.12 | 29.28 |
| 70° | 30 | 29.44 | .. |
| 60° | 15 | 29.28 | .. |

From these results it is evident that the standard time and temperature of extraction of meal is suited also for extraction of the one-fourth quantity of meats. Experiments using a larger proportion of meats showed low results. Whether this was due to incomplete extraction or to a possible change of the specific gravity curve for such high per cents. was not determined.

TABLE 13.

PER CENT. OF OIL IN COOKED MEATS

| Temperature | 5 min | | 10 min | | 15 min. | |
|---|---|---|---|---|---|---|
| | I. | II. | I. | II. | I. | II |
| 50° | 29.84 | .. | 29.72 | .. | 29.60 | 29.72 |
| 60° | 29.60 | .. | 29.88 | .. | 30.34 | .. |
| 70° | 29.40 | 29.88 | 30.22 | 30.76 | .. | .. |

Again the extraction at 60° for 15 minutes is sufficient.

That the presence of moisture does not affect the extraction was demonstrated by extractions on both raw and cooked meats at 60° C., for 15 minutes, thus:

TABLE 14.

RAW MEATS (moisture 8.95):

| | I. | II. |
|---|---|---|
| Hydrous | 29.28 | .. |
| Anhydrous | 29.40 | 29.12 |

COOKED MEATS (moisture 5.73):

| | I. | II. |
|---|---|---|
| Hydrous | 30.84 | .. |
| Anhydrous | 31.40 | 31.00 |

*Hulls.*—After transferring 40 grams of hulls to the Erlenmeyer flask it was found necessary to pack the hulls with a glass rod in order to insure complete covering with 100 cc. of carbon tetrachloride. No wire gauze strainer was necessary in filtering the extract.

TABLE 15

| Temperature. | Time. min. | Per cent. of oil. Soxhlet extraction. | Sp. gr. method. |
|---|---|---|---|
| 60° | 5 | 0.30 | 0.25 |
| 60° | 10 | .. | 0.32 |
| 60° | 15 | .. | 0.25 |
| 60° | 30 | .. | 0.25 |

It is proposed to extend the investigation to the determination of oil in linseed products, and of fats in feedstuffs, tankage, etc.

University of North Carolina,
Chapel Hill, N. C., October 29, 1908.

# THE STABILITY OF ROSIN AT SLIGHTLY ELEVATED TEMPERATURES*

BY CHAS. H. HERTY AND W. S. DICKSON

On heating American rosin to 120°-140° C. in a current of air freed from carbon dioxide, Schwalbe[1] obtained a copious precipitate of barium carbonate by conducting the gases from the flask in which the rosin was heated into a solution of barium hydroxide. He interpreted this as evidence of the decomposition of the abietic acid in the rosin with consequent formation of the hydrocarbon abietene, and pointed out the effect such a decomposition must have upon the melting point and saponification number of rosin.

From evidence obtained during the course of another investigation we were inclined to doubt the accuracy of Schwalbe's interpretation. Accordingly the following investigation was undertaken, the results of which show that rosin which has not been long exposed to the oxygen of the atmosphere can be heated indefinitely at 140° without showing any evidence of the formation of carbon dioxide, provided oxygen and moisture are excluded from the flask in which the rosin is heated.

## EXPERIMENTAL

At the outset Schwalbe's experiment was repeated. For heating the rosin a 200cc. Erlenmeyer flask was placed in a beaker containing cottonseed oil. The air entering the flask was freed from carbon dioxide by being drawn through three wash bottles filled with a strong solution of sodium hydroxide. After leaving

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[1] Zeit. angew. Chem, 18, 1852.

the flask the air was passed through a test tube half filled with freshly filtered barium hydroxide solution. Another wash bottle containing a solution of sodium hydroxide was placed between the barium hydroxide tube and the aspirator, a suction pump. A blank experiment with this apparatus showed no precipitation of barium carbonate after drawing air through for one hour. A repetition of Schwalbe's experiment showed a copious precipitation of barium carbonate.

The possibility that this evolution of carbon dioxide might be due to the action of the air upon the heated rosin, aided by the presence of slight traces of spirits of turpentine in the rosin, led to a repetition of the experiment using spirits of turpentine alone instead of rosin. With a specimen of old spirits of turpentine an even heavier precipitation of barium carbonate occurred than with rosin. No question of the splitting off of a carboxyl group could arise here. A specimen of freshly distilled turpentine showed also a precipitation of barium carbonate, but not so marked as with the old specimen.

Having proved that the spirits of turpentine alone was capable of giving the precipitation observed by Schwalbe, a current of steam was passed through molten rosin for eight hours in order to completely remove all spirits of turpentine. Repeating Schwalbe's experiment with this rosin the precipitation was still observed. Evidently the presence of slight traces of spirits of turpentine was not alone responsible for the precipitation observed.

It remained therefore to determine the possible influence of oxygen and of moisture on the formation of carbon dioxide from the molten rosin. Accordingly, the current of air drawn through the fllask was freed first from carbon dioxide by sodium hydroxide, then dried by passing through sulphuric acid. A marked precipitation of barium carbonate was again observed. Then moist nitrogen was substituted for air. The nitrogen was prepared by drawing air through three wash bottles filled with an alkaline solution of pyrogallic acid. Again a precipitation of barium carbonate occurred. Finally a current of dry nitrogen was drawn through the flask and after all air had been expelled the rosin was heated to 140° and kept at this temperature for seven hours without the slightest precipitation in the tube containing barium hydroxide.

The above experiments were carried out on a specimen of freshly distilled rosin from the oleoresin of *Pinus heterophylla* (Cuban Pine). This suggested the possibility that Schwalbe had used a rosin from the oleoresin of *Pinus Palustris* (Longleaf Pine). Accordingly a fresh specimen of rosin was prepared from the oleoresin collected from a single tree of this species. On heating the rosin in dry nitrogen to 140°, again no trace of precipitation was noticeable.

Finally Schwalbe states that his experiment was made upon a sample of commercial American rosin. On heating such a sample in dry nitrogen we found an abundant precipitation of barium carbonate.

Four factors therefore may have entered into the formation of the carbon dioxide observed in Schwalbe's experiment: first, traces of spirits of turpentine in the rosin; second, moisture; third, oxygen in the air conducted through the flask; and fourth, oxygen absorbed either by the oleoresin previous to distillation or by the rosin on standing in the air. The explanation of a probable splitting off of a carboxyl group is demonstrated to be erroneous by using a sample of rosin recently distilled from a fresh specimen of the oleoresin and heating in a current of dry nitrogen.

And yet, paradoxical as it may at first appear, Schwalbe's explanation is even more than true: not in regard to "American rosin", but as applied to the acids of the oleoresin from which rosin is prepared. In order to avoid any elevation of temperature in the preparation of these acids, freed from the other constituents of the oleoresin, a specimen of the oleoresin of *Pinus heterophylla* was dissolved in ether. From this ethereal solution the potassium salts of the acids were precipitated by addition of a saturated water solution of potassium hydroxide. The crystal broth was mixed with glass wool to render it more permeable to an extractive, then thoroughly extracted with ether in a Soxhlet extractor. After removal of the last traces of ether the salts were dissolved in water, the solution acidified with dilute hydrochloric acid, and the precipitated acids washed and dried. On heating a specimen of these acids in the apparatus described above in a current of dry nitrogen the mass melted at 65°-70°, immediately evolution of carbon dioxide began as shown by the escape of gas bubbles from the molten mass, and the heavy precipitation of barium carbonate.

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## PROCEEDINGS OF THE EIGHTH ANNUAL MEETING OF THE NORTH CAROLINA ACADEMY OF SCIENCE, HELD AT TRINITY COLLEGE, DURHAM, N. C., APRIL 30TH AND MAY 1ST, 1909.

The Executive Committee met at 3:30 P. M. Friday, April 30th. Present Prof. W. H. Pegram, and Vice Pres. J. J. Wolfe and Secy. E. W. Gudger *ex officio*. Messrs. Franklin Sherman Jr. and T. G. Pearson were asked to become members pro tem. The report of the Secretary-Treasurer was listened to and commended to the Academy. The following persons were nominated and elected to membership in the Academy: Z. P. Metcalf, Assistant Entomologist, Dept. Agriculture, Raleigh, N. C.; S. C. Clapp, Inspector, Division of Entomology, Dept. Agriculture, Raleigh, N. C.; C. A. Shore, Director, State Laboratory of Hygiene, Raleigh, N. C.; Henry D. Aller, Director, Fisheries Laboratory, Beaufort, N. C.; W. G. Chrisman, State Veterinarian, Dept. Agriculture, Raleigh, N. C.; J. L. Burgess, Soil and Crop Specialist, Dept. Agriculture, Raleigh, N. C.

The following amendments, proposed by the Secretary, were recommended to the favorable action of the Academy:

Amendment I.

Art. II. Sec. 1 be amended by the addition of the following words after "privileges of the Academy":

The application for membership shall be accompanied by the dues for the current year—the same to be returned to the applicant should he not be elected.

Amendment II.

Art. V. Sec. 1 be stricken out; the following be inserted in its place: The official organ of the Academy shall be the Journal of the Elisha Mitchell Scientific Society published at the University of North Carolina. The editor of the Journal and the Secretary of the Academy shall compose the editorial board for the Academy, subject to the general control of the Executive Committee of the Academy.

The Committee, after explanation as to why it had not been done sooner, authorized the Secretary, as soon as the list of active members is perfected, to print and send to each member of the Academy a copy of the revised constitution of the Academy including the roll of members.

The Committtee recommended to the Academy that a committee on membership be appointed to work up a greater membership for the Academy among the scientific men of the state, and that the Secretary be *ex officio* chairman thereof.

At 4:30 Vice Pres. Wolfe, in the absence of President Tait Butler, called the Academy to order and the remainder of the afternoon was devoted to the presentation of papers. Before adjournment the chair appointed the following committees: to audit Treasurer's accounts, Charles H. Herty, W. N. Hutt, and F. Sherman Jr.; on resolutions, Collier Cobb, J. F. Lanneau, and S. B. Shaw; on nominations, H. V. Wilson, Franklin Sherman, Jr., and A. S. Wheeler.

At 8:30 P. M. the Academy met in Memorial Hall and was cordially welcomed to Trinity College by Dean W. P. Few. On behalf of the Academy, response was made by retiring President T. G. Pearson. Mr. Pearson then lectured on "The Work of the Audubon Society in Preserving Rare Forms of Bird Life in America," using lantern slide illustrations. At 9:30 P. M. the Faculty of Trinity College gave a reception to the members of the Academy.

At the reassembling of the Academy at 9:45 A. M. Saturday, May 1st, a short business meeting was held. The minutes of last meeting were read and approved. The actions and recommendations of the Executive Committee as noted above were unanimously confirmed. The Auditing Committee reported that the books of the Secretary-Treasurer showed a balance on hand of one hundred five dollars and eleven cents ($105.11), agreeing with his bank book. The Nominating Committee's report was adopted and officers elected for the ensuing year as follows:

President, Prof. W. C. Coker, University of North Carolina, Chapel Hill, N. C.

Vice President, Prof. W. H. Pegram, Trinity College, Durham, N. C.

Secretary-Treasurer, Dr. E. W. Gudger, State Normal College, Greensboro, N. C.

Executive Committee:

Mr. H. H. Brimley, State Museum, Raleigh, N. C.

Prof. C. W. Edwards, Trinity College, Durham, N. C.

Dr. W. S. Rankin, Wake Forest College, Wake Forest, N. C.

The Chair appointed as the Committee on Membership, the Secretary *ex officio*, Mr. Franklin Sherman Jr., Dept. Agriculture, Raleigh, N. C.; Prof. John F. Lanneau, Wake Forest College, Wake Forest, N. C.; Prof. Collier Cobb, University of North Carolina, Chapel Hill, N. C.

Following the business meeting, the reading of papers was resumed. At 1:45 the Academy adjourned for lunch. At 3:20 the Academy reconvened and the remainining papers on the program were presented. Prof. Edwards' paper on "College Entrance Requirements in Science in North Carolina" provoked considerable discussion. On motion the Chair appointed the following committee to collect data and report at our next meeting on "Science Teaching in North Carolina High Schools Preparatory to Entrance for College":

Prof. C. W. Edwards, Trinity College, Durham, N. C.

Prof. A. S. Wheeler, Chapel Hill, N. C.

Dr. H. V. Wilson, Chapel Hill, N. C.

Dr. W. C. Coker, Chapel Hill, N. C.

Prof. W. N. Hutt, Raleigh, N. C.

The committee on resolutions brought in a resolution of appreciation and thanks for the many courtesies received at the hands of the Faculty and Ladies of Trinity College.

At 4:20 the Academy adjourned.

The following members were present at the meeting:

H. H. Brimley, W. C. Coker, Collier Cobb, R. O. E. Davis, H. N. Eaton, C. W. Edwards, E. W. Gudger, C. H. Herty, W. N. Hutt, Archibald Henderson, J. F. Lanneau, Mrs. C. D. McIver, J. E. Mills, T. G. Pearson, W. H. Pegram, J. H. Pratt, F. L. Stevens, W. B. Streeter, Franklin Sherman, S. B. Shaw, H. V. Wilson, A. S. Wheeler, J. J. Wolfe, G. M. MacNider, Z. P. Metcalf, S. C. Clapp, G. A, Roberts—27.

The following papers were presented:

*The Chemistry of Scrape Formation*, Chas. H. Herty, University of North Carolina, Chapel Hill, N. C.

"Scrape" is the hardened resinous mass which forms gradually on the scarified surface of certain pines during the turpentine season, March to November. Determination of the unsaponifiable matter in various oleo-resins shows that the amount of this material is relatively high in trees which do not form scrape (*Pinus Heterophylla*) and low and variable in scrape forming trees (*Pinus Palustris*). The explanation is offered that the amount of scrape formed is approximately inversely proportionate to the per cent of unsaponifiable matter present, this being a honey-like, non-crystallisable substance which acts as a retardant of crystallization in the oleo-resin after it exudes from the tree. Confirmation of this idea is furnished by analyses of the oleoresins of Loblolly Pine (*P. Taeda*) and old Field Pine (*P. Echinata*).

*The Great Comet Next Spring*, John F. Lanneau, Wake Forest College, Wake Forest, N. C.

*A Study of Varieties*, W. N. Hutt, Department of Agriculture, Raleigh, N. C.

Plants of economic value being subject to domestication usually give rise to numerous varieties.

Horticultural plants afford better material for study than agricultural, because the latter are usually treated collectively while the former are necessarily treated as individuals.

Varieties of a century ago as listed by Wm. Coxe, of Barlington, N. J. in 1818 as compared with modern varieties.

| | No. listed by Coxe. | Listed now. |
|---|---|---|
| Apples | 133 | 2138 |
| Pears | 65 | 2567 |
| Peaches | 38 | 449 |
| Plums | 18 | 522 |

Of the 133 apples listed by Coxe, 43 or 32 per cent of them are of foreign origin. Now, exclusive of recent Russian importation, but four are found in present variety lists. Variety lists are becoming more and more native American.

Pear varieties are largely foreign, but most useful varieties for American conditions are natives e. g. Seckel, Keifer.

Of early varieties of apples as listed by Coxe but nine are found in the lists of today. Of 2138 varieties of apples in modern lists only 85 are the result of seed planting and selection. All remainder are chance seedlings. The life of a chance seedling is a good example of the "fortuitous law of chance." One may survive, millions are lost.

Reasons for varieties not "coming true."

Reasons for "running out" of varieties.

The history of the corn is an example of variation. The tomato is in a state of evolution due to high feeding under domestication.

The impossibility of obtaining ideal varieties is because our ideals advance with our knowledge and many of the characteristics we would want in an ideal variety are incompatible in one individual.

Ideals are well illustrated by opposites.

We want—

Apples that will grow farther south.

Peaches that will grow farther north.

Pears that will not blight and that have no grit and sand in them.

Oranges that are not bitter and pithy.

Quinces that are not wooden.

Grapes without seeds.

Berries that are not seedy, and the small boy wants the stomach-acheless green apple. In short we want the rainbow, but as we advance it ever recedes.

*Social Science: Report on the White House Conference on Care of Dependent Children*, W. B. Streeter, Superintendent of the North Carolina Children's Home Society, Greensboro, N. C.

**Syllabi of Conference Resolutions**

1. HOME CARE: Children of worthy parents or deserving mothers should, as a rule, be kept with their parents at home.

2. PREVENTIVE WORK: Society should endeavor to eradicate causes of dependency like disease and to substitute compensation and insurance for relief.

3. HOME FINDING: Homeless and neglected children, if normal, should be cared for in families, when practicable.

4. COTTAGE SYSTEM: Institutions should be on the cottage plan with small units, as far as possible.

5. INCORPORATION: Agencies caring for dependent children should be incorporated, on approval of a suitable State Board.

6. STATE INSPECTION: The State should inspect the work of all agencies which care for dependent children.

7. INSPECTION OF EDUCATIONAL WORK: Educational work of institutions and agencies caring for dependent children should be supervised by State educational authorities.

8. FACTS AND RECORDS: Complete histories of dependent children and their parents should be recorded for guidance of child-caring agencies.

9. PHYSICAL CARE: Every needy child should receive the best medical and surgical attention, and be instructed in health and hygiene.

10. CO-OPERATION: Local child-caring agencies should co-operate and establish joint bureaus of information.

11. UNDESIRABLE LEGISLATION: Prohibitive legislation against transfer of dependent children between States should be repealed.

12. PERMANENT ORGANIZATION: A permanent organization for work along the lines of these resolutions is desirable.

13. FEDERAL CHILDREN'S BUREAU: Establishment of a Federal Children's Bureau is desirable, and enactment of pending bill is earnestly recommended.

*The Planet Mars*, John F. Lanneau, Wake Forest College, Wake Forest, N. C.

*The Photographic Equipment of a Biological Laboratory and Some Microphotographs Useful in Teaching*, H. V. Wilson, University of North Carolina, Chapel Hill, N. C.

The photographic equipment of the new Biological Laboratory of the University of North Carolina was described. For life-size photographs or reductions a Bausch and Lomb Tessar lens used in a Century View camera mounted on a Folmer and Schwing tilting laboratory stand, has proved useful. For low magnifications the Zeiss microplanars 4 and 5 held in a Century View camera or in a Zeiss horizontal-and-vertical camera are used, either with reflected or transmitted light. In the latter case the object (an entire microscope slide, for instance, covered with growing organisms) is placed on a wooden box over a very large aperture through which the light is sent from a large plane mirror. For microphotographs the Bausch and Lomb apparatus is used, either with a Thompson automatic electric lamp or with an acetylene lamp so made as to fit the same light box. For freshly mounted balsam or for glycerine slides the vertical microscope with prism-arrangement offers great advantage. For low magnifications of large fields the Zeiss microplanars 1-3 without ocular, warrant the praise that has been given them. The microphotographs exhibited were of preparations illustrating points of general interest in the fields of vertebrate embryology and histology.

*New Occurrence of Monazite in North Carolina:* Joseph Hyde Pratt, State Geologist, Chapel Hill, N. C.

Published in full in this issue.

*College Entrance Requirements in Science in North Carolina:* C. W. Edwards, Trinity College, Durham, N. C.

*An Alteration in the Direction of Growth that may be induced in Sponges:* H. V. Wilson, University of North Carolina, Chapel Hill, N. C.

One of the common sponges in Beaufort harbor, *Stylotella* sp., develops oscular lobes which grow up toward the surface of the water when the sponge rests on the bottom. If now such a sponge with a set of well developed lobes be laid on its side in a large aquarium, growth takes place at many points on the lobes and at right angles to their long axis. This growth leads in the course of a week to the development of a new set of oscular lobes which again extend up towards the surface of the water but at right angles to the former lobes, whose terminal oscula have now disappeared.

*The Wistar Institute Journals and the Need for their Support:* H. V. Wilson.

It was pointed out that the growth in the biological departments of colleges led to the need of suitable organs for publication, and that it was to the manifest interest of these departments to lend financial support to such journals as those of the Wistar Institute.

*A New Species of Water Mold:* W. C. Coker, University of North Carolina, Chapel Hill, N. C.

In Oct. 1908 a species of *Leptolegnia* was found at Chapel Hill, N. C. and has been kept growing in the laboratory since. It proves to be near the long lost *Leptolegnia caudata* DeBary of Germany, but seems to be distinct enough to be considered a new species.

*Delayed Opening of Cones in Certain Species of Pines:* W. C. Coker.

Cones of *Pinus tuberculata* from California and *Pinus serotina* from South Carolina were shown. Though mature for about eight years they had not opened. This tendency is developed to such an extent in *P. tuberculata* that the cones seem never to open until the wood on which they are borne is dead.

*Exhibit of a Double-flowered Sarracenia and a New Variety of Elliott's Gentian:* W. C. Coker.

Double flowers of *Sarracenia rubra* were shown from Hartsville, S. C. They have not before been known in the genus. Other specimens exhibited were a white variety of *Gentiana Elliottii* from Society Hill, S. C. and leaves and fruits of *Acer Floridana* from Chapel Hill, N. C.

*Some Notes on the Song Periods of Birds:* C. S. Brimley, Raleigh, N. C.

The writer commenced taking notes on what species of birds were in song at Raleigh, N. C., during the last week of June, 1908, and this paper gives the results obtained up to the end of April, 1909.

*On the Number of Species of Birds that can be Observed in one Day at Raleigh, N. C.:* C. S. Brimley.

Published in full in this issue.

*Geology and the Lumber Market.* Collier Cobb, University of North Carolina, Chapel Hill, N. C.

*Studies in Soil Bacteriology III, Concerning Methods for Determination of Nitrifying and Amonifying Powers*, by F. L. Stevens and W. A. Withers, assisted by J. C. Temple, W. A. Syme, J. K. Plummer and P. L. Gainey, North Carolina Experiment Station, Raleigh, N. C.

Since nitrate nitrogen is generally believed to be the most readily available and most valuable form of nitrogen for plants, means of measuring the ability of various soils to produce nitrate nitrogen, to nitrify, are desirable. To determine nitrifying power; to recognize deficiencies in nitrifying power; to ascertain the cause of such deficiencies when they exist and to find means of correcting them, all require quantitative studies of this factor of soil fertility. To make quantitative determinations of nitrifying power that shall be of broad utility and general value, methods must be devised the trustworthiness of which can be recognized.

Three conditions to be recognized in considering the nitrifying ability of a soil are:

1. The nitrifying organisms present.
2. The physical and chemical fitness of the soil for the proper functioning of those organisms.
3. The nitrifying efficiency of the soil plus the organisms existing in it.

NITRIFICATION INOCULATING POWER (NIP)

The index may be called the Nitrification Inoculating Power which may be abbreviated as NIP. It recognizes only the factor of the live organisms present, taking no account of the fitness or unfitness of the soil for their activity. It does not regard bacterial species but merely the complex present in the soil at the time it is tested.

Theoretically the NIP may be high in a soil in which, owing to adverse chemical or physical conditions, no nitrification really occurs. Theoretically nitrifying bacteria may be present in goodly number in a soil possessing physical and chemical conditions favorable to rapid nitrification yet no nitrate appear, owing to the presence of other species of the bacteria or of substances which either inhibit the action of the nitrifiers or destroy the nitrate which they produce so that nitrate does not appear as a final product. NIP considers only the efficiency of the organisms present to give nitrate as a final product under circumstances favorable to their growth.

NITRIFYING CAPACITY (NC)

The second index, fitness of the soil as regards factors other than its content of living things, i.e. its capacity to support nitrification provided proper organisms be present, may be designated as its Nitrifying Capacity, abbreviated as NC. NC regards only the non living factors. Theoretically soil may be of high NC but still fail to nitrify owing to lack of proper organisms, i.e., to lack of proper NIP. Theoretically a soil may be of low NC yet show high NIP. NC will on final analysis be found to depend upon physical conditions and chemical composition including water content.

### NITRIFYING EFFICIENCY (NE)

The third index may be designated on the nitrifying efficiency of the soil, abbreviated NE, which regards the efficiency of the soil as a whole to produce nitrates as a final product. NE may be low owing to lack of NIP or to lack of NC or both. NE will be high if there be high NIP associated with high NC.

Proper determination of NE will show whether a given soil is in normal vigorous nitrifying condition. If such is not the case, determination of NC and NIP will show whether it is the bacterial or non bacterial factors which are at fault and may lead to correction of existing defects.

### CONDITIONS FOR DETERMINING THESE INDICES

Directions for determining these three factors of Nitrification are worked out on the basis of a large mass of experimental evidence and the results of a large number of analyses made in accordance with these methods are presented.

*Observations on Bird Life of Great Lake in Craven County, North Carolina:* H. H. Brimley, Curator State Museum, Raleigh, N. C.
[Read by title].

*Senses of Insects.* By Franklin Sherman, Jr., Entomologist, Department of Agriculture, Raleigh, N. C.
Published in full in this issue.

*Methods of Reproduction Among Insects:* Z. P. Metcalf, Department of Agriculture, Raleigh, N. C.

*Some Unrecognized Factors Affecting the Potential Differences Developed in an Induction Coil:* C. W. Edwards, Trinity College, Durham, N. C.
[Read by Title].

*Oral Gestation Among Teleostean Fishes.* E. W. Gudger, State Normal College, Greensboro, N. C.

Oral Gestation is not uncommonly practiced by Siluroid and Cichlid Fishes. Many marine, estuarine, and freshwater Catfishes of Central and South America, India, and Australia carry their eggs and young in their mouths. With one possible exception, it is always the male who thus incubates the eggs.

Among the Cichlids of South America, Africa, and Syria this habit is very prevalent. In these fishes it is generally the females who thus care for their progeny.

Scattering cases of this habit among other Teleosts are occasionally met with, especially among species belonging to the genera *Apogon* and *Cheilodipterus*. It seems probable that further research among these latter forms will extend our knowledge of this curious habit which is invariably associated with unusually large size of the eggs.

The writer has been engaged for fifteen months in working up the literature of this extraordinary habit in fishes. This work is being done for the Bureau of Fisheries, and will be issued in its publications.

*The Linear Classification of the Cubic Surface.* Archibald Henderson, University of North Carolina, Chapel Hill, N. C.

The speaker considered the twenty-one different types of the cubic surface (neglecting the two scrolls) reduced to canonical form with reference to the straight lines lying wholly upon the surface. By proper choice of constants, he succeeded in representing, in each case, the lines in position with reference to the fundamental tetrahedron. He exhibited diagrams, in color, of the lines, with proper reference to each other and to the fundamental tetrahedron, for all twenty-one types of the cubic surface.

*The Terminal Bud of the Sweet Gum, Liquidambar Styraciflua.* E. W. Gudger, State Normal College, Greensboro, N. C.

This tree has on the ends of its lateral branches terminal buds of two kinds. One is of ordinary size and contains only leaves and an embryonic branch. The other kind is very large and swollen.

Dissection or subsequent development on the tree shows that this contains a cone made up of the familiar sweet gum balls — it is seemingly a terminal bud devoted solely to the production of flowers. Later, the lowest ball (sometimes the two lowermost) develops an extraordinarily long pedicel, and the stem bearing the cone breaks off just above the point of attachment of this pedicel leaving but one ball of the six or eight to come to maturity. About this time a very small leaf bud makes its appearance just below the base of the cone and this lateral bud later becomes the terminal bud which by its growth elongates the branch.

*Social Science: The Work of the Woman's Association for the Betterment of Schools.* Mrs. Charles D. McIver, Field Secretary Woman's Betterment Association of North Carolina, Greensboro, N. C.

*Notes on the Petrography of the Granites of Chapel Hill, N. C.* H. N. Eaton, University of North Carolina, Chapel Hill, N. C.

*Some Results of Municipal Milk Inspection in Raleigh, N. C.* F. L. Stevens, North Carolina Experiment Station, Raleigh, N. C.

The results of three years analyses are collated and compared.

During the period 1097 samples were analysed bacteriologically and chemically.

The improvement in the milk bacterially during the cool months, the warm months, and by entire years, is shown in the following tables.

TABLE I SHOWING IMPROVEMENT DURING COOL MONTHS

Bacteria per cubic centimeter.

| Year | No. Analysed | More than 500,000 | | More than 1,000,000 | | More than 5,000,000 | |
|---|---|---|---|---|---|---|---|
| | | No. | % | No. | % | No. | % |
| 1905 | 72 | 25 | 34 | 18 | 25 | 2 | 3 |
| 1906 | 136 | 54 | 39 | 31 | 22 | 10 | 7 |
| 1907 | 176 | 32 | 18 | 18 | 10 | 0 | 0 |
| 1908 | 193 | 35 | 18 | 18 | 9 | 2 | 1 |

TABLE II SHOWING IMPROVEMENT DURING SUMMER MONTHS

Bacteria per cubic centimeter.

| Year | No. Analysed | More than 500,000 | | More than 1,000,000 | | More than 5,000,000 | |
|---|---|---|---|---|---|---|---|
| | | No. | % | No. | % | No. | % |
| 1906 | 136 | 78 | 57 | 57 | 41 | 23 | 17 |
| 1007 | 166 | 65 | 39 | 43 | 26 | 7 | 4 |
| 1908 | 160 | 51 | 32 | 23 | 14 | 1 | 1 |

TABLE III SHOWING IMPROVEMENT IN BACTERIAL CONTENT

Bacteria per cubic centimeter.

| Year | No. analysed | More than 500,000 | | More than 1,000,000 | | More than 5,000,000 | |
|---|---|---|---|---|---|---|---|
| | | No. | % | No. | % | No. | % |
| 1906 | 272 | 132 | 48 | 88 | 32 | 35 | 12 |
| 1907 | 342 | 97 | 28 | 61 | 17 | 7 | 2 |
| 1908 | 353 | 86 | 24 | 41 | 11 | 3 | 1 |

**Watering and Skimming**

While bacterial content is of most significance as regards health of Raleigh citizens, the question of watering and skimming of milk offered for sale is not without interest to the buyers. Similar inspection of our records as shown in the two following summaries shows that milk of low fat content or of low content of "solids not fat" occurred frequently three years ago while at present such milk is very rarely found. Many reports were made during the first years of the inspection of undoubted cases of watering or skimming, or both together. Such practice is now rare.

A summary of the findings regarding the fat content for the several years is as follows:

| Year | No. of samples analysed | No. of samples, below legal amount of fat. | Per cent of samples below legal amount of fat. |
|---|---|---|---|
| 1905 | 37 | 7 | 19 |
| 1906 | 286 | 33 | 11 |
| 1907 | 353 | 26 | 7 |
| 1908 | 353 | 14 | 4 |

Showing clearly the improvement wrought during these years.

SUMMARY OF THE FINDINGS REGARDING "SOLIDS NOT FAT."

| Year | No. of samples containing below 8 per cent. | Per cent samples containing below 8 per cent |
|---|---|---|
| 1905 | 12 | 28 |
| 1906 | 42 | 14 |
| 1907 | 54 | 12 |
| 1908 | 25 | 7 |

In light of the above facts it can be justly claimed that the inspection has wrought much improvement in our milk supply.

E. W. GUDGER,
Secretary.

# ON THE NUMBER OF SPECIES OF BIRDS THAT CAN BE OBSERVED IN ONE DAY AT RALEIGH, N. C.

BY C. S. BRIMLEY

Last fall while Mr. Sherman, Mr. Z. P. Metcalf and myself were in conversation, Mr. Metcalf asked me how many species of birds I had ever noted in one day here, adding that in Ohio in January, he had seen as many as 33, excluding English Sparrow. From this time Mr. Sherman and myself became also interested in the subject, and have made many notes on the birds seen in a single day.

A summary of our observations may be added before going into any detail.

| | | | | |
|---|---|---|---|---|
| Nov. 1908. | Total No. species observed | 55. | Most in a day | 34 |
| Dec. 1908. | ,, | 50 | ,, | 29 |
| Jan. 1909. | ,, | 49 | ,, | 34 |
| Feb. 1909. | ,, | 43 | ,, | 30 |
| Mar. 1909. | ,, | 60 | ,, | 40 |
| Apr. 1909. | ,, | 95 | ,, | 62 |

The species observed in November were:

1. American Woodcock
2. Killdeer
3. Mourning Dove
4. Bob-white
5. Great Horned Owl
6. Red-shouldered Hawk
7. American Sparrowhawk
8. Turkey Vulture
9. Black Vulture
10. Southern Hairy Woodpecker
11. Southern Downy Woodpecker
12. Pileated Woodpecker
13. Yellow-bellied Sapsucker
14. Red-headed Woodpecker
15. Flicker
16. Phoebe

17. Crow
18. Blue Jay
19. Redwinged Blackbird
20. Meadow Lark
21. Rusty Blackbird
22. Purple Grackle
23. American Goldfinch
24. Purple Finch
25. English Sparrow
26. Savanna Sparrow
27. White throated Sparrow
28. Field Sparrow
29. Song Sparrow
30. Swamp Sparrow
31. Slate colored Junco
32. Towhee
33. Cardinal
34. Blueheaded Vireo
35. Migrant Shrike
36. Pine Warbler
37. Myrtle Warbler
38. American Pipit
39. Cedar Waxwing
40. Mocking Bird
41. Carolina Wren
42. Winter Wren
43. Tufted Tit
44. Carolina Chickadee
45. Brownheaded Nuthatch
46. Red-breasted Nuthatch
47. White-breasted Nuthatch
48. Brown Creeper
49. Goldcrowned Kinglet
50. Rubycrowned Kinglet
51. Hermit Thrush
52. American Robin
53. Bluebird
54. Fox Sparrow
55. Unidentified Duck

The largest number of species observed in any one day was on the 17th, when Messrs. F. Sherman, Z. P. Metcalf and myself took a day's tramp to the river (Neuse) and back. The species observed on this day were woodcock, both vultures, hairy, downy, and red-headed woodpeckers, and sapsucker, phoebe, crow, meadow lark, cardinal, junco, towhee and six sparrows, (all except fox), goldfinch, both warblers, pipit, mocker, both wrens, both tits, two nuthatches (except redbreasted), gold crowned kinglet, hermit thrush, robin, and bluebird.

The species observed in December were the same as those in November, except that no duck, killdeer, bob-white, dove, owl, sapsucker, rusty blackbird, purple grackle, blueheaded vireo, or waxwings were seen, while pine siskin, Wilson's snipe, marsh, and Cooper's hawks and redtailed hawks were added to the winter's list, making a net loss of five species for the month.

In January the species observed were the same as those in December, except that American woodcock, Wilson's snipe, redtailed hawk, redheaded woodpecker, towhee, pipit and shrike, were not observed, while in addition to the December birds, great blue heron, dove, yellow palm warbler, bob-white, purple grackle and Bewick's wren were noted, a net loss of one.

The longest list of species seen in one day was by myself on Jan. 12th, and the observations covered only half a day. The species were: red-shouldered hawk, dove, both vultures, 3 woodpeckers, phoebe, crow, 6 sparrows, goldfinch, siskin, cardinal, junco, pine and myrtle warblers, redwing blackbird, mocker, Carolina and winter wrens, brown creeper, tufted and Carolina tits, both kinglets, brown headed nuthatch, bluebird, hermit thrush and robin.

The February list dropped dove, Cooper's and Marsh hawks, pileated woodpecker, purple grackle, red breasted nuthatch, and phoebe, and added only shrike, a net loss of six species.

The March list added chipping sparrow, bluegray gnatcatcher, blue headed and white eyed vireos, black and white, and yellow throated warblers, and Louisiana water thrush, all spring arrivals, and also dove, killdeer, Wilson's snipe, redtailed hawk, phoebe, yellow bellied sapsucker, pileated woodpecker, purple grackle, towhee, all observed before this winter, and vesper sparrow formerly a winter visitor at Raleigh but of late years only observed very sparingly, also kingfisher and brown thrasher, which are occasional in winter. Two species were dropped, Bewick's wren and pine siskin, making a net gain of 17 species.

The largest number of species were observed on the 31st during a half day's tramp, by Sherman and myself. The list of 40 species was as follows: great blue heron, Wilson's snipe, kingfisher, pileated woodpecker, flicker, dove, phoebe, crow, redwing, blackbird, 7 sparrows, cardinal, junco, purple finch, pine, myrtle, yellow-throated, and black and white warblers, white eyed vireo, Louisiana water thrush, Carolina and winter wrens, mocker, thrasher, Carolina and tufted tits, ruby crowned kinglet, robin, hermit thrush, bluebird, brown headed nuthatch, red shouldered hawk, both vultures, and purple grackle.

The total April list far exceeded that of the previous months, owing to the arrival of summer visitors and transients. The birds noted up to and inclusive of the 27th were as follows:

1. Pied-billed Grebe
2. Great Blue Heron
3. Green Heron
x4. American Bittern
5. King Rail
6. American Coot
7. Wilson's Snipe
8. Spotted Sandpiper
9. Lesser Yellowlegs
x10. Bob-white
x11. Mourning Dove
x12. Turkey Vulture
13. Black Vulture
14. Screech Owl
x15. Red-shouldered Hawk
x16. Cooper's Hawk
17. Red-tailed Hawk
18. Belted Kingfisher
19. Whippoorwill
x20. Chimney Swift
x21. Rubythroated Humming Bird
x22. Downy Woodpecker
x23. Red-headed Woodpecker
x24. Flicker
25. Phoebe
x26. Crested Flycatcher
27. Wood Pewee
28. Kingbird
29. Bobolink
x30. Redwinged Blackbird
x31. Meadow Lark
x32. Blue Jay
x33. American Crow
x34. American Goldfinch
35. Pine Siskin
x36. Purple Finch
x37. English Sparrow
x38. White-throated Sparrow
39. Vesper Sparrow
x40. Savanna Sparrow
41. Henslow's Sparrow
x42. Field Sparrow
x43. Chipping Sparrow
44. Song Sparrow
x45. Swamp Sparrow
46. Bachman's Sparrow
47. Slate colored Junco
x48. Cardinal
x49. Towhee
x50. Rose-breasted Grosbeak
51. Indigo Bunting
52. Scarlet Tanager
x53. Summer Tanager
x54. Purple Martin
55. Barn Swallow
x56. Roughwinged Swallow
x57. Red-eyed Vireo
58. Blue-headed Vireo
x59. Yellowthroated Vireo
x60, White-eyed Vireo
x61. Black and White Warbler
x62. Parula Warbler
x63. Yellow Warbler
x64. Blackthroated Blue Warbler
x65. Myrtle Warbler
x66. Yellowthroated Warbler
x67. Pine Warbler
x68. Prairie Warbler
x69. Hooded Warbler
x70. Kentucky Warbler
x71. Ovenbird
x72. La. Water Thrush.
x73. Maryland Yellowthroat
x74. Yellowbreasted Chat

x75. American Redstart
x76. Mockingbird
x77. Catbird
x78. Brown Thrasher
x79. Carolina Wren
80 Winter Wren
81 Bewick's Wren
x82 House Wren
x83 Tufted Tit
x84 Carolina Chickadee
x85 White breasted Nuthatch
86 Red breasted Nuthatch
x87 Brown-headed Nuthatch
88 Brown Creeper
x89 Ruby-crowned Kinglet
x90 Blue-gray Gnatcatcher
91 Hermit Thrush
x92. Wood Thrush
x93 American Robin
x94 Bluebird
95 Orchard Oriole
Several unidentified ducks also seen

The largest number seen in any one day was on the 22nd when Mr. Sherman and myself took a whole day's tramp for the express purpose of looking for birds and succeeded in observing 62 species, being those marked with an x in the list above.

The observations on which this paper was founded were furnished mainly by myself but I am much indebted to Messrs. Stephen C. Bruner, Franklin Sherman, Jr., and Z. P. Metcalf for additional records, many of which were of great interest.

# SOME NOTES ON THE SONG PERIODS OF BIRDS

BY C. S. BRIMLEY

The observations on which this paper is based were begun in late June of last year, 1908, and have been carried on uninterruptedly ever since. This it will be noticed leaves a gap of six or seven weeks in May and part of June in which no data has as yet been collected at Raleigh. I have however some data from Lake Ellis in late May of 1908, and it may also be assumed with reason that any bird found in full song as late as the end of April and also in late June, continued in song during the intervening period.

With these explanations I will now take up the different species, beginning with those that are permanent residents.

*Carolina Wren.* This bird justly heads the list by virtue of its industry, its song period being the whole year, and the amount of song it indulges in seeming to be about the same at all seasons.

*Mockingbird.* Has two song periods, one from early March to early July, and from mid-September to mid-November.

*Robin.* Early March to early July, and occasionally as late as early August.

*Cardinal.* Early March to early July, also heard twice in November, and twice in January.

*Field Sparrow.* Late February to late August.

*Pine Warbler.* Commences singing during any warm spell in January and continues, interrupted by any cold spell, until March at which period it may be said to be in full song. It continues in song all March and April, has been heard also in late May at Lake Ellis and once in late June at Raleigh. There is also a second song period in September and one is occasionally heard in late fall and winter.

Taking up next the summer birds, we find the following facts:

*Chipping Sparrow.* Has about the same song period as its near relative the *Field Sparrow*, viz: from its arrival in March till late August, when it becomes silent though the species does not leave us till October or November.

*Yellow Throated Vireo.* Continues in song from its arrival in early April till its departure in mid-September.

*White Eyed Vireo.* Also sings during its whole stay from late March to mid-October.

*Red Eyed Vireo.* Sings from its arrival in mid-April till mid-July only, although it does not leave us till mid-October.

Of the summer residents among the warblers, all are in full song on their arrival here, which varies in the case of the different species from the last week in March to the last week in April.

The song of different species ends about as follows:

*Yellow Warbler.* Noted singing up to the last week in July, which is the time the species seems to leave us for the south, the few birds seen later in the season are apparently visitors from further north and are silent.

*Yellow Breasted Chat.* Heard up till mid-July only, but occurs till mid-September.

*Maryland Yellow Throat.* Heard up till mid-July only, but stays as late as late October.

*Hooded Warbler.* Heard up till early July, but stays as late as late September.

*Parula Warbler.* Heard as late as July 1, but stays as late as mid-October, being very abundant in the fall migrations.

*American Redstart.* Heard till early July, occurs up to mid-October.

*Yellowthroated Warbler.* Heard at Lake Ellis in late May, not heard at Raleigh after observations were started on June 12, 1908. Stays till the third week in September.

Other summer birds on which notes were taken are:

*Summer Tanager.* Heard up to June 21, also once each in July, August, and September at intervals of almost exactly a month (on the 13th, 13th, and 14th, respectively). Stays till late September.

*Catbird.* Heard till late July and once in August. Stays normally as late as the third week in October.

*Wood Thrush.* Heard till mid-July only, stays till mid-October.

*Blue Grosbeak* Heard till early July, and also once in August. Stays till mid-September.

*Indigo Bunting.* Heard till mid-July and once in August. Stays till mid-October.

The remainder of my notes relate mainly to our winter visitors, a considerable proportion of which do not sing at all during their stay with us. I have data concerning the following:

*Rubycrowned Kinglet.* Arrives in mid-October, and leaves in late April. Was heard singing on one very warm day in early November, and not again till late March or early April, from which time it continues in song until it leaves for the north, in late April.

*Hermit Thrush.* Arrives in mid-October, stays till late April, so far only heard singing on the same very warm day in November alluded to above.

*Song Sparrow.* Arrives in mid-October, and has been observed as late as April 11th. Heard singing sporadically throughout its entire stay, except the first and last weeks.

*White-throated Sparrow.* Arrives at the same time as the preceeding, but does not leave till a month later. Heard singing sporadically all its stay, and coming into full song in early April.

*Fox Sparrow.* Length of stay from about early November till late March, but heard singing only on two occasions in November, three in December, and three in January, but on some of these dates the birds were singing a great deal.

*Meadow Lark.* Stays with us from early or mid-October till mid or late April, but was only heard singing from mid-February to early April.

The above notes are, I am aware, quite crude and meagre but they seemed worth while presenting, as the subject has been very little touched upon.

The times limiting the song periods or length of stay are in all cases inclusive.

# THE PROBABLE ELECTRICAL NATURE OF CHEMICAL ENERGY*

BY A. H. PATTERSON

In a recent paper Dr. J. E. Mills has expressed some interesting views on the nature and source of Chemical Energy[1]. His argument may be summarized as follows: When 16 grams of oxygen are mixed with 2.016 grams of hydrogen at 0° C, nothing happens, but if a minute spark (supplying a negligible amount of heat) be applied, combination takes places, 18.016 grams of water are formed, and 68,511 calories of heat are given out. Whence comes this relatively enormous amount of heat energy? Suppose we take 16 grams of oxygen and 2.016 grams of hydrogen at —273° C, and add enough heat energy to bring them to 0° C. Dr. Mills shows that the following amount will be needed: For the hydrogen: Raising the temperature from —273° C, 1844.8 calories, supplying heat of fusion and of vaporization, 280.4 calories; total 2125.2 calories. For the oxygen: Raising the temperature through the same range, 1065.4 calories, supplying heat of fusion and of vaporization, 906.7 calories; total, 1972.2 calories. So that 4097.5 calories would be added to the hydrogen and oxygen in bringing them up from —273° to 0° C. Now the energy necessary to raise 18.016 grams of water through the same range of temperature would be 2886.9 calories, divided as follows: For raising the temperature, 1447.4 calories; for supplying heat of fusion, 1439.5 calories. The water at 0° C of course still retains this energy, but since 4097.4 calories were given to the hydrogen and oxygen,

* A paper read at the Fifteenth General Meeting of the American Electrochemical Society, at Niagara Falls, Canada, May 8, 1909.

1 Transactions Am. Electrochem. Soc., 14, 35 (1908).

and only 2886.9 calories are retained by the water, a balance of 1210.5 calories remains to be given out during combination. *But the amount given out in combination is 68,511 calories, leaving 67,300 calories unaccounted for. Whence comes this energy? In what form did it previously exist?* It was clearly possessed by the hydrogen and oxygen in their solid form at —273° C. Dr. Mills conceives that every atom of a substance possesses at —273° C a specific chemical energy (though he does not use this term), partly in the potential form, due to "chemical attraction" between it and one or more other atoms, and partly in the kinetic form, which latter condition must be fulfilled if the system of which the atom is a part is to be a stable one[2]. This chemical attraction, or force, or affinity "is probably never directly affected by a rise in temperature,"[3] and the 67,300 calories of energy above mentioned "appears to have been held, intact as it were, neither increased nor diminished, by the changes of temperature, pressure and volume necessary to raise the hydrogen and oxygen to their condition at 0° C," and "represents the total energy change of the three reactions:

$$H_2 = H + H$$
$$\tfrac{1}{2}O_2 = \tfrac{1}{2}(O + O)$$
$$H + H + O = H_2O$$

when taking place at —273° C."

The reactions liberated this store of energy, but how they did so, and in what form the energy previously existed, Dr. Mills does not attempt to explain. It is possible that some light may be thrown upon this question by a recourse to the electron theory.

### THE ELECTRICAL THEORY OF CHEMICAL COMBINATION

It may be well to give first a brief account of some of the fundamental ideas of this theory, as well as of some of its recent developments. It is now a familiar story how the idea of electrons arose. Helmholtz, in his Faraday lecture[4], spoke of electricity

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2 Meyer, Kinetic Theory of Gases, 2nd English Ed., p. 344.

3 See also Nernst, Theoretical Chemistry, 4th Eng. Ed., p. 688.

4 Journal Chemical Soc., 1881, p. 39.

being "divided into definite elementary portions which behave like atoms of electricity" in the conduction of a current through a liquid electrolyte. Maxwell had already proposed that "we call this constant molecular charge" (in electrolysis) "for convenience of description, one atom of electricity."[5] Lorentz in 1880, in order to explain the phenomena of light, formulated a theory[6] which regarded an atom of matter as a complex structure consisting of these "atoms of electricity," for which the name "electrons" had been suggested by Stoney, who as early as 1874 had succeeded in calculating the value of the electric charge on one electron. Various theories of the exact structure of an atom out of electrons have been put forth[7], but the most widely accepted view at present is that of Sir J. J. Thomson, who regards an atom as being built up of a sphere of positive electricity of uniform density, throughout which the negative electrons (Thomson prefers to call them "corpuscles") are distributed in various orbits, revolving about the center of the sphere. The number of electrons in an atom is proportional to the atomic weight.[8] The enclosing positive charge acts as though it were concentrated at its center, and is supposed to attract each electron with a force which varies as the direct distance of the electron from the center of the sphere. The "sphere of positive electrification" occupies a vastly greater space than the total volume of all the electrons. These latter, being similarly charged, repel each other according to the inverse square of the distance law.

The electrons are in extremely rapid orbital motion about the center of the atom, the average number of revolutions being about 500 million million per second, and these give rise to light waves. In a neutral atom, the sum of the negative charges on the electrons is exactly equal to the positive charge of the enclosing sphere. In this case the stability of the electron grouping inside the atom depends upon the number of electrons, the way they are arranged in the orbits, and the strength of the enclosing positive charge.

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5 Electricity & Mag., 1st Ed., 1873, p. 312.

6 Propagation of Light, Wied. Ann., 1880, p. 9.

7 Lodge, Electrons, pp. 148-150.

8 Thomson, Corpuscular Theory of Matter, p. 164.

Some atoms easily lose electrons, on account of the instability of their electron groupings. Other atoms have a tendency to acquire electrons from outside, if such increase in number lends greater stability to their electron groupings. The complete solution of the problem of the stability or instability of given electron groupings seems to be beyond the power of mathematics at present, as the electron orbits lie at all angles, but the analytical solution of the case where the orbits of the electrons are supposed to be confined to one plane has been given by Prof. Thomson,[9] and shows that very few groupings of electrons, comparatively speaking, are at all stable. When an atom loses electrons, it thereby loses negative electricity, and a residual positive charge remains. Such an atom would in general belong to an electropositive element. If an atom acquires electrons, its negative charge preponderates over its positive, and the atom acts like an electronegative element. Valency depends on the number of electrons lost or gained. We must not suppose, however, that all the atoms of, let us say, a divalent electropositive element are at any given time in the same condition of having lost two electrons each. In the hurly-burly of atomic and molecular motions and encounters atoms will alternately lose and gain electrons very rapidly, perhaps millions of times per second, but if in the case of the supposed element the atoms have *a tendency to get into the condition represented by the loss of two electrons per atom rather than into any other condition*, the element will have a positive valency of two, and will react with one or more other substances of negative valency as rapidly as the atoms get into the proper condition, owing to the loss or gain of electrons, to go into combination. This requires more or less time, of course, thus agreeing with the facts of chemistry, as no reaction is instantaneous, but proceeds according to an exponential law. *Combination ensues when two or more atoms, carrying unlike charges, and coming near enough for the purpose, are pulled more closely together by the electrostatic lines of force between their charges, and held together tightly in a molecule.* As Ramsay says: "Chemical action is the occasional result of . . . collisions, . . . . but the process of combination is a comparatively slow one, and

[9] Phil. Mag., March, 1904.

. . . a collision followed by a combination is a comparatively rare event."[10]

With the assumption that chemical affinity is simply electrostatic attraction between charges of electricity, Sir J. J. Thomson has worked out with great ingenuity a series of model atoms, composed of spheres of uniform positive electrification, with varying numbers of electrons revolving in varying numbers of orbits inside these spheres, and has shown that such a series of atoms would show the same properties, periodically recurring, as are actually observed in the elements arranged according to the periodic law.[11] The theory explains more or less satisfactorily the recurring electropositive and electronegative character of the elements, and why the same element acts sometimes electropositively, and at other times electronegatively; the recurrence of corresponding groups of lines in the spectra of elements of the same periodic-law group; the valency of the elements, including the zero valency of the argon group, and also the different valency of the same element under different circumstances; the formation of molecules by the union of atoms of the same element; the existence of unsaturated compounds, such as $PCl_3$; the formation, in solution of certain elements (for example, Br and I) of both positive and negative ions, the element appearing at both anode and cathode during electrolysis; the apparent change in the properties of the carbon atom when combined with different elements; the thermoelectric effects, and in fact, nearly all of the phenomena of physics and chemistry. Especially in the explanation of the phenomena of optics and radioactivity has the new theory been of great advantage, and without it the facts of radioactivity, at least, would seem to be entirely inexplicable. Arrhenius has also extended the theory to explain astronomical and meteorological phenomena, such as auroras, the solar corona, magnetic storms, etc. But while the electron theory provides us with the broadest working hypothesis of modern times for the correlation and unification of physical, chemical, and biological phenomena, it cannot be claimed that it

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10 The Electron as an Element, Journal Chem. Soc., Apr., 1908, p. 777.

11 Electricity and Matter, p. 117 *et seq.*; Corpuscular Theory of Matter, Chapter VI.

is in any sense final. One of its founders, indeed, has quite recently pointed out the need for revision or modification of some of its fundamental ideas.[12] Nevertheless, it has already proved to be one of the strongest aids to research which physical science has known.

### THE SOURCE OF CHEMICAL ENERGY

Can we obtain, on the electrical theory, any information concerning the source and nature of the energy liberated in chemical reactions? Take the reaction

$$H + O + H = H_2O$$

for example. Before union we have two hydrogen atoms, each carrying one positive electron charge, and one oxygen atom carrying two negative electron charges. What amount of energy do these charged atoms represent?

The potential of a sphere bearing a charge is equal to $Q/r$ where $Q$ is the charge on the sphere (in electrostatic units) and $r$ is the radius of the sphere (in centimeters). The resultant potential is given in electrostatic units, an electrostatic unit being equal to 300 volts.

The electron charge has been independently determined by different observers. H. A. Wilson found it to be $3.1 \times 10^{-10}$ electrostatic units;[13] J. J. Thomson found by another method[14] the value $3.4 \times 10^{-10}$. Using the mean value of N (number of molecules in 1 c.c. of a gas under normal conditions of pressure and temperature) given by Meyer,[15] viz., $6.1 \times 10^{19}$, we find the corresponding value of the electron charge to be $3.7 \times 10^{-10}$.

The value obtained by J. Perrin[16] is $4.1 \times 10^{-10}$, and by Rutherford and Geiger[17] is $4.65 \times 10^{-10}$ electrostatic units. Max Planck calculated the value, from theoretical considerations, to be

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12 See article by H. A. Lorentz, Phys. Zeitschr., Sept. 1, 1908.
13 Phil. Mag., [VI], 5, 429 (1903).
14 Cond. of Elec. Thro. Gases, 2nd Ed., p. 158.
15 Kin. Th. of Gases, 2nd Ed., p. 333.
16 Comptes Rendus, 147, 594-596 (1908).
17 Proceedings of the Royal Society, 81, A, 162-73.

$4.69 \times 10^{-10}$, and Millikan and Begeman found the value $4.06 \times 10^{-10}$.

These last values, being the latest determinations, are probably more correct than former ones. In the following calculation Rutherford's value will be used.

As to the radius of a molecule, estimates vary widely. Meyer gives values ranging from $2 \times 10^{-8}$ cm. to about $16 \times 10^{-8}$ cm.,[18] but leans toward the lower figure.[19] The radius of an atom is shrouded in equal doubt, but we may assume $10^{-8}$ cm. as approximately correct. Using these values we find that the potential, $V$, of an atom carrying an electron charge is $4.65 \times 10^{-2}$ E. S. units, or about 14 volts. The energy of a charged body is $\frac{1}{2} QV$ ergs, or, applying our values, the energy of a charged hydrogen atom is $\frac{1}{2} \times 4.65 \times 10^{-10} \times 4.65 \times 10^{-2} = 10.8 \times 10^{-12}$ ergs. The energy of the charged divalent oxygen atom is twice this amount. The energy of the charged atoms entering into combination to form one molecule of water is therefore about $4.3 \times 10^{-11}$ ergs. Next comes the question of the number of molecules in 1 c.c. of water. This is as uncertain as the values of the electron charge, but it is probably about $3.4 \times 10^{22}$. On this estimate the number of molecules in 18 grams of water is $6.2 \times 10^{23}$, and the energy of the charged atoms of hydrogen and oxygen would be, before combination, $6.2 \times 10^{23} \times 4.3 \times 10^{-11} = 2.7 \times 10^{13}$ ergs: $= 2.7 \times 10^{6}$ joules, $= 6.4 \times 10^{5}$ calories, or *640,000 calories*. When the charged atoms rush together into combination, this energy, which existed as potential energy of charge, is partly given out, and *it is at least suggestive to note that this amount of energy is quite sufficient to account for the 67,300 calories given out in the formation of 18.016 grams of water, and is, moreover, of about the magnitude we should expect*, as we do not imagine the atoms to come close enough in combination to release all their energy.

Too much importance, however, must not be given to the number found, 600,000 calories, for the energy of charge of the hydrogen and oxygen atoms may be much greater or much smaller than

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18 *Loc. cit.*, pp. 320, 331.

19 Perrin gives $2.6 \times 10^{-8}$ cm. as the diameter of a molecule of oxygen. *Loc. cit.*

this. I wish merely to make the point that whatever the potential electrical energy of the hydrogen and oxygen atoms may be before combination, it is less afterwards by the amount given out, *viz.*, 67,300 calories. If the charges on the hydrogen and oxygen atoms "sparked into" each other, *all* of the electrical energy would be given out, but this does not occur.[20] *The hydrogen and oxygen atoms (in a molecule of water) may be considered then as coming quite near each other when in combination, near enough to render the molecule electrically neutral, but not near enough to equalize the charges, and not near enough to prevent stray lines of force from producing a "residual attraction" between the molecules.*

THE RESIDUAL ATTRACTION

Dr. Mills in his paper says: "It is possible . . . that the molecular attraction is merely the residual chemical attraction."[21] The electrical theory would simply substitute the word "electrical" for the word "chemical" above. For various reasons Dr. Mills thinks that the "attractive forces . . . which proceed from a particle are definite in amount. If this attraction is exerted upon another particle the amount of the attraction remaining to be exerted upon other particles is diminished." If chemical attraction is electrostatic attraction, we have these conditions exactly fulfilled, and also have an explanation why this force, and the energy due to it, is independent of temperature changes, for the number of "lines of force" proceeding from a given charge is a perfectly definite quantity, unaffected by temperature. The explanation of the "residual attraction" which the electrical theory offers is given by Prof. Thomson as follows:[22] The attraction between charged bodies is greater when these bodies are conductors, in which electrons are able to move about freely, than between non-conductors bearing the same charges, for the conductors allow the corpuscles to move into the most advantageous positions, as it were, and electrostatic induction comes into play. The residual

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20 Lodge, Electrons. p. 154.

21 *Loc. cit.*

22 Corpuscular Theory of Matter, p. 135 *et seq.*

attraction between saturated atoms and molecules will therefore be a function of the mobility of the electrons inside the atoms. "This mobility may not be the same for the atoms of the different elements, and may be different for the same atom according as it is exerting positive or negative valency; in other words, the attraction of an atom may not be wholly exhausted when its valency is satisfied, and the residual attraction may depend not only upon the nature of the atom, but also upon whether it is exerting its positive or negative valencies." The interesting question arises whether this residual attraction is greater or less when an atom carries a positive charge than when the charge is negative. It must be remembered that the theory supposes that the extra electron in a negative monovalent atom is united to a positive atom by lines of force, and that these lines spring from the relatively large surface of the positive atom and converge to the minute electron on the other atom, somewhat as the network of ropes from a balloon converge to the basket beneath. The intensity of the electric field, therefore, at the surfaces of the two atoms is not the same, and we may expect a difference in the residual attraction which an atom exerts when negatively and when positively charged. "In the compound $CH_4$," says Professor Thomson,[23] "the carbon is supposed to carry a charge of — 4, and in CO (if the oxygen is tetravalent) a charge of + 4; the value of $a$[24] for $CH_4$ is 0.0379, and that for CO is less, viz., 0.0284, although the residual attraction of oxygen is probably greater than that of hydrogen. This, as far as it goes, is in favor of the view that the residual attraction of carbon is greater when it is negatively than when it is positively charged." The residual attraction also appears to exist between molecules, and acts to form aggregates of molecules, especially around negative ions, which seem to exert much more effect than positive ions. "It has been found that in carefully dried gases the velocity of the negative ion is considerably greater than that of the positive when the electrical forces acting on them are equal. If,

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23 *Loc. cit.*

24 The cohesion factor in Van der Waals' formula.

however, a little water vapor is added to the gas, it produces a considerable diminution of the velocity of the negative ion, while it hardly affects that of the positive. It seems quite possible that this is due to the residual attraction of the OH radical in the water for a negative charge, making the water molecules attract the negative ions more strongly than they do the positive ones, so that the water molecules will tend to attach themselves to the negative ions, and by loading them up diminish their velocity."[25] Thomson showed years ago that negative electrification had a decidedly greater effect in promoting condensation than positive,[26] and C. T. R. Wilson found that negative ions require less cooling by expansion to make them act as condensation nuclei in dust-free air than positive ions.[27] It is quite probable that these phenomena are explained in the same way. The electrical theory would indicate that there must always be some residual attraction, even in the inactive monatomic gases.

The liquefaction of helium shows this, though for helium the value of $a$ is the smallest known.

### THEORY OF ELECTRICAL CONDUCTION

So far it is significant and interesting to note that the reasoning of the chemist and the physicist, though from different points of view, and expressed in different language, leads to practically the same conclusions. In the case of electrical conduction the difference is rather pronounced between Dr. Mills' ideas and those of the electrical theory. Briefly stated, the electrical theory supposes that in metals electrons are easily detached from the atoms, and under the action of an electric force, as when a wire connects the terminals of a voltaic cell, the electrons rapidly pass from atom to atom through the wire in the direction of the positive terminal. This stream of electrons is equivalent to a *positive current flowing in the opposite direction*, *viz.*, along the wire from the positive to the negative terminal. The kinetic energy of these moving electrons smashing, as it were, into the atoms, causes increased atomic

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[25] J. J. Thomson, *Loc. cit.*

[26] Phil. Mag., 36, 813 (1893).

[27] Phil. Transactions, 193, 289 (1899).

motion, and the wire becomes heated. In the case of metals a rise in temperature retards the motion of the electrons in some way, and the conductivity decreases. In carbon, however, a rise in temperature seems to give the electrons greater freedom of motion, and so the "hot resistance" of a carbon filament is less than the "cold resistance." In the case of non-conductors, like the rare earths, the electrons are only set free by strong heating. In the Nernst glower, for example, conductivity begins only when the temperature is about 1,200° C. The salts of the metals are poor conductors, because the atoms of the metal have already lost electrons, in going into chemical combination, and it is difficult to loosen others and pull them away from the positively charged atoms. In solution, however, the ions of salts are free to move, and we have a double stream of positive and negative ions moving in opposite directions under the electric stress. In gases also there can be no conduction without ionization. In the vacuum tube discharge we have a peculiar case, for we get a stream of *free electrons, unassociated with atoms*, going in one direction, and a stream of positively charged atoms moving in the other. If this latter stream is prevented from reaching the cathode the discharge is stopped.[28]

Dr. Mills' theory of conduction is somewhat ambiguous. He says: "I have in my own mind connected the power to conduct electricity, whether the substance is in the solid, liquid, or gaseous condition, not primarily with molecules, nor with ions, nor even perhaps with electrons. The essential requisite appears to me to be a free, that is, an unabsorbed attraction." It is difficult, on this hypothesis, to see why mercury, for example, should not be a better conductor than silver, as its atoms seem to be less firmly bound together; nor why the resistance of selenium should change so marvelously with the degree of illumination to which it is subjected; nor why increase of temperature, which drives atoms further apart, should not always increase conductivity; nor how the vacuum tube discharges and the action of electric valves may be explained; nor how the change of resistance of bismuth in a magnetic field may be accounted for.

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28 Lodge, Electrons, p. 39.

However, the object of this paper is merely to emphasize the fact that physicists and chemists, reasoning from different viewpoints, often reach practically the same general conclusions, which is evidence for the truth of these conclusions, and further that the electrical theory, in spite of certain artificial features, seems to offer the best and clearest idea of the source of chemical energy, the mechanism of chemical combination, ionization, dissociation, etc., and the most rational explanation of the various phenomena of physical science.

UNIVERSITY OF NORTH CAROLINA,
CHAPEL HILL, N. C.
February 16, 1909.

# NEW OCCURRENCE OF MONAZITE IN NORTH CAROLINA

BY JOSEPH HYDE PRATT

In 1897 there was forwarded to the office of the North Carolina Geological Survey a package containing a sample of mineral for identification. No letter accompanied this package and the only clue to the locality from which the mineral came was the postmark, which was Mars Hill. The mineral was turned over to the writer for examination and was found to be monazite. There were a number of fairly well developed crystals of unusual size; but the majority of the pieces did not show any crystal faces but were pseudo-crystalline, due to parting parallel to *c* and *m*. An attempt was made to locate the sender of the specimens without success and although many inquiries have been made in the vicinity of Mars Hill and the place has been visited a number of times, no clue to the occurrence of this monazite was obtained until in the fall of 1908 another specimen of monazite was seen by the writer while travelling in Madison County. A systematic search was then begun for the mineral with the result that the occurrence was definitely located.

References have been made to the occurrence of monazite at Mars Hill, Madison County by F. A. Genth* who states that monazite occurs in "large cleavable masses sometimes from 3 to 4 inches across and of a yellowish brown color from Mars Hill, Madison County." He does not, however, give any further statement regarding locality. In Dana's Mineralogy† it is stated that monazite occurs "in considerable quantities in Madison County, North Carolina, yielding angular fragments due to parting." Judging

*Bull. 74, U. S. Geological Survey, 1891, p. 77.
†6th. ed., 1892, p. 752.

from these brief notices of monazite in Madison County, it is very probable that the specimens found at that time were picked up on top of ground by some of the farmers in the vicinity of Mars Hill and no record was kept of where they were actually obtained.

Judging from the occurrence of this mineral in the South Mountain region of North Carolina where it was known to occur in the gneissic rocks and especially in those portions that have been pegmatized, instructions were given to the men trying to locate the monazite to look for it in the gneissic or granitic rocks that were more or less pegmatized. The occurrence of the monazite was finally located on a hill to the west of Whiteoak Creek, a branch of Ivy River approximately 3 miles southwest of Mars Hill and 6 miles nearly due east of Marshall. It is on a tract of land owned by Mr. N. P. M. Corn.

The country rocks of this section are Carolina gneiss and Cranberry granite named and described by Mr. Arthur Keith.* The Carolina gneiss is of Archean age and consists chiefly of mica gneiss and mica schist but includes other gneisses, granites and diorites with small lenses of marble. The origin of this Carolina gneiss is uncertain, but it is possible that most of the mass was once a granite and that it has been metamorphosed into its present condition. In this particular vicinity this Carolina gneiss occurs as outliers from the main formation and is not inter-banded with the Cranberry granite. Immediately to the east there is a large mass of Roan gneiss and this is also observed further to the west. The Cranberry granite as it occurs in this vicinity is also in the form of outliers or apophyses from the main mass lying to the north and west. As described by Mr. Keith, this granite is an igneous rock composed of quartz and orthoclase and plagioclase feldspar with biotite, muscovite, and, in places, hornblende as additional minerals. There are a number of accessory minerals as magnetite, ilmenite, garnet and epidote, found in this granite. This granite occasionally contains pegmatite areas and, on the Whiteoak Creek, a great deal of the gneiss and granite was pegmatized.

*U. S. Geological Survey, Asheville Folio, No. 116, 1904, pp. 2 and 3.

There are no extensive areas of rocks outcropping on this hillside. Occasionally small boulders of the partially decomposed granite were observed containing more or less epidote and ilmenite forming a sort of a ledge running around the hill about a third of the way to its top. About 100 feet up the hillside a shaft has been sunk to a depth of 45 feet. The rocks were decomposed throughout this distance so that no blasting whatever was necessary. On account of the excessive decomposition of the rocks, it was difficult to determine what the rocks at this particular point were. They had the appearance, however, of being decomposed Cranberry granite. The section exposed by the shaft showed the rocks to be more or less pegmatized and to carry monazite the whole depth of the shaft. The mineral seemed to occur in the pegmatized band of the rock which, in the shaft as exposed, had a width of 2½ to 4 feet and does not occur in any sense as a vein formation.

The monazite, which was of a clove brown color, was found in fragments or rough crystals varying from pieces the size of a pea up to a large rough crystal that weighed almost exactly 60 pounds. No attempt was made at this time to determine the percentage of monazite that the rock would carry. One or two pans full of the monazite-bearing portion of the rock were dug out, which gave nearly a pound of monazite. The property is now being developed and later a more detailed account will be given of the percentage of monazite in the rock and its commercial value.

As stated above, the monazite is in the form of irregular fragments, rough crystals and cleavable masses. One of the best crystals observed was a part of a mass that weighed 6½ pounds, which was made up of crystals in parallel position with some of the faces very perfectly developed. Another crystal, which was well terminated, weighed 12 ounces. It measured 2¾ inches in the directiom of the *b* axis and 1½ inches in the direction of the *a* axis and was 2¼ inches long. The prismatic faces of the *a* pinacoid were well developed as was also the unit pyramid *w:* The lower end of the crystal showed no terminations. The faces observed on these crystals were identified by means of the contact goniometer and were as follows: *a* (100); *m* (011); *w* (101)

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$v$ ($\bar{1}11$).

The basal plane $c$ was not observed on any of the crystals but was observed as one of the parting or cleavage planes. Parting planes were also very prominently developed parallel to $m$.

The masses of the mineral were very pure and one analysis to determine the percentage of monazite in the mass showed it to contain 99.5 per cent monazite. No chemical analyses have been made of the mineral beyond the determination of thoria. This determination, which was made in the laboratory of the Welsbach Light Company, showed this monazite to contain 5.06 per cent thoria, which is equal to the percentage of thoria in the best commercial monazite found in the South Mountain region.

The size of the crystals of monazite found in this deposit and the possibility yf its developing into an occurrence of commercial value make the discovery a most interesting one and its further development will be watched with a great deal of interest not only by those interested in this mineral from a commercial standpoint but also by the mineralogist who will be interested in obtaining large crystals of this mineral.

N. C. GEOLOGICAL AND ECONOMIC SURVEY.

# THE SENSES OF INSECTS

BY FRANKLIN SHERMAN, JR., DEPT. AGR., RALEIGH, N. C.

*The Five Senses.* In the higher animals we are familiar with the five senses, or means by which the animals learn concerning the things around. These are (1) *Touch*, (2) *Taste*, (3) *Sight*, (4) *Hearing* and (5) *Smell*. If we can imagine a person, or animal, bereft of *all* of these, such an individual would be worse than helpless—it would scarcely be more than merely organic. We well know that many of the lower forms of life have one or more of these senses imperfect or entirely lacking.

Within the great group of Insects, which stand high in the series of invertebrated animals, we find all of these five senses present in some degree,— some insects having more of them, or having some more highly developed, than other insects.

1. *The Sense of Touch* in insects is not confined to any one part of the body; and in this they are like other animals, But, just as the hands and fingers are the principal organs of touch in man, just so the *antennae* (the "horns" or "feelers" which are so evident on the head of many insects) are the principal organs of touch in most insects. Almost any insect when crawling about will keep the antennae in constant motion, feeling about from side to side as if to ascertain the nature of the objects around it. Many insects, however, have the antennae so small that they are not noticeable to our eyes, — but that they are very important organs to the insect class as a whole is shown by the fact that all insects have them in one or another of their stages of development. Many insects have around the mouth-parts delicate organs known as *palpi* which are very sensitive to touch, and which are used more especially to feel of particles of food, etc.

Insects have a quite well-developed nervous system, with fine ramifications of sensitive nerves extending to all parts of the body. Consequently the surface of the body at any point may act as a center of touch, just as with us. But many insects have a firm covering or armor of *chitin* (a substance resembling horn) through which the nerves do not extend. This is especially the case with the hard-shelled Beetles, some of which are so firm as to be crushed with the fingers only with much effort. With such insects the sense of touch must be confined largely to the antennae, delicate parts of the legs, and the thin membrane between the segments of the body, etc. On the other hand caterpillars, grubs, maggots and immature insects generally, have rather soft bodies and the entire body-surface may be quite sensitive to touch. All who have experimented with the common horn-worms on tobacco are familiar with this fact. With regard to the Senses of Touch, then, we may conclude that while it is not confined to any part or parts, yet it is more developed in the extremities, and especially in those all-important organs, the antennae.

2. *The Sense of Taste* is not, so far as we know, very highly developed in insects, or at least positive organs of taste are not often discernible. There is in some insects (grasshoppers and their relatives) a tongue-like organ in the mouth by means of which they probably taste their food, but on the whole this sense is not believed to be highly developed.

There is a fact in this connection, however, which may easily (and perhaps rightly) be interpreted to indicate that the sense of taste is well developed. An adult insect will almost invariably deposit her eggs on the same kind of plant on which it was itself reared and which its young requires though there may be hundreds of other plants about. This may be due to an acute sense of taste on the part of the adult, or it may be only acuteness of some other sense, such as smell. The adult of the common Tent-caterpillar in our orchards seldom makes a mistake in depositing eggs on plants which will nourish the larva (more especially apple and choke-cherry) yet the adult insect has only very imperfectly developed mouth-parts and is thought not to take any food in the adult state,—and here the adeptness at selecting proper plants would not seem to be due to a sense of taste on the part of the adult.

A butterfly will invariably lay eggs on the proper food-plant of the larva which eats the leaf, but the adult butterfly can only lap up liquid, such as nectar,—in such a case the sense of taste can hardly be responsible for the accurate choice by the adult egg-laying female.

3. *The Sense of Sight* is evidently one of the most important of the senses to insects, serving especially in the matter of self-preservation from enemies. Some subterranean or cave-inhabiting insects are wholly blind, or are only slightly responsive to light and darkness,—but with many other insects the sense is extremely acute. Whoever has attempted to collect the species of dragonflies ("snake-doctors" or "devils darning-needles" or "mosquito-hawks" as they are sometimes called) does not need to be told that their sense of sight is remarkably keen, and that they can use it to great effect either in eluding their enemies or in capturing their prey. The organs of sight in insects are the eyes, and these are always located on the head. There is an idea, quite prevalent in many places, that the horse-fly has eyes beneath the base of its wings. The little organs found at this place in all true flies are known as the *halteres* and have nothing to do with the sense of sight. They seem to serve a more or less double purpose as balancers and as rudders in maintaining and guiding the insect while in flight. Some butterflies and moths have conspicuous marks on the wings which are often called eye-spots, but they have no connection with the sense of sight. Let us repeat, then, that all of the organs of sight, so far as we know them, are located on the head, and are the organs known as eyes. The eyes, however, are of two kinds, (1) There are the large "compound eyes," consisting of a great number of individual eyes massed together like the cells of a honey-comb,—each one performing its own separate individual part in making the completed picture which the insect sees. (2) There are in some insects single, separate eyes, known as "ocelli." These are usually two or three in number and are well separated from one another. They are so small as to pass unnoticed except by students, and their presence or absence, number and arrangement, form excellent characters for classification. What difference there may be in function between these two kinds of eyes, is yet a matter of con-

jecture. Some believe that the compound eyes are adapted for long-range vision and the simple eyes for more detailed study by the insect at close range. It has also been suggested that perhaps one set of eyes is adapted to viewing of objects in motion, and the other for scrutinizing objects at a standstill. But as the simple eyes (or *ocelli*) are not present in many whole groups of insects which live an active life in the open air, it seems certain that they are not nearly so important as the compound eyes, and may indeed, be only remaining fragments that were not consolidated into the compound eyes, when nature slowly moulded them during the ages gone.

It is also a curious fact, worthy of mention in this connection, that investigation indicates that insects "see things" in inverted order from ourselves, that the refractive lenses in the eyes throw an inverted image on the cornea. Photographs have been taken through the compound eyes of insects, and when developed, show an inverted image. If this inference is correct, the insect sees us standing, as it were, on our heads, — but as all other objects would be likewise inverted, we would appear just as natural to them in that position, as they look to us in our method of seeing.

4. *The Sense of Hearing* is in some insects located in distinct organs while with others we do not know that the sense even exists at all. But in those insects which "sing" or give forth voluntary sounds, it seems certain that the sense of hearing must be developed, for we can conceive of no purpose which such sounds could serve unless they are audible to others of the same kind, so that they would serve to indicate danger, or the presence of mates, etc. There is considerable variation in location of the sense of hearing. In the common mosquitoes of the genus *culex*, we have strong evidence that the antennae serve as organs of hearing. The female when flying makes a shrill noise which is much louder than the sound made by the male. We might therefore infer that the sound produced by the female is audible to the male, and that, as the males make little or no noise these insignificant sounds would not be audible to the female. This seems to be the case, for the antennae of the male mosquito is very much more complex and delicate than those of the female, —and it has been found

that when shrill sounds of the same pitch as those made by the female mosquito are sounded close by a male mosquito, the antennae vibrate in unison with the sound, indicating that through them the sound is conveyed.

On the other hand certain moths, in which neither sex produces sound, have the antennae more developed in the males than in the females, but here the explanation lies in the sense of smell, and not in the sense of hearing.

With the crickets, katydids and those grass-hoppers in which the antennae are longer than the body, the organs of hearing, which we may liken unto ears, are located on the tibiae of the front legs near where they join the femur. (A more simple way of expressing it is to say that the ear is on the fore-arm near the elbow of the front leg). Each "ear" is, in appearance, merely an opening into the leg covered with a thin membrane, similar to the head of a drum, and this indeed does correspond to the "drum" of our own ears. This opening may be round, oval, or appear merely as a slit. In those grass-hoppers in which the antennae are shorter than the body, the "ears" are situated on the sides of the abdomen close up to the thorax, behind the hindermost (third) pair of legs,—and each appears as quite a larger opening into the body, the opening being covered by a membrane or "drum."

We must conclude, therefore, that with insects the sense of hearing is quite variable in its development, and in the location of its organs. With some there seems to be no sense of hearing, while with those which do hear, the auditory organ may be in various positions, or the power to hear may be (apparently) developed in only one sex.

*Sounds Produced by Insects.* Closely associated with the sense of hearing is the power and inclination to produce voluntary sounds. Those animals which produce voluntary sounds almost always (perhaps invariably so) possess the power of hearing. The methods by which insects produce sounds are various. With katydids and crickets the males chirp, while the females do not make sounds,—and the chirping is produced by chafing the front wings together. The female mosquito makes a shrill note by the rapid vibration of the wings in flight, while the males are silent. Certain species of grass-hoppers make a crackling sound by striking the hind legs and wings together while in the air. The Cicadas (known by the common names of "Locusts," "Dry-flies," etc.) sing by means of rapid vibration of a special organ in the abdomen which is covered by a movable flap, plainly visible, but which exists only in the males, the females being noiseless. It is worthy of remark that all insect songs or sounds are *instrumental or mechanical*, and we know of no such thing as real vocal sounds in insects.

5. *The Sense of Smell* is evidently highly developed in some insects while among others it seems to be poorly developed or entirely absent. With many it is of extreme importance in finding food. The organs of smell are the antennae. Insects which feed upon carrion and like substances, or which deposit their eggs on such matter seem to find these substances almost exclusively by the sense of smell, finding it with evident ease even if it is at some distance and concealed from sight. On the other hand if their antennae are removed many seem unable to find their food even though it is quite near and in full view. This indicates that the sense of sight is defective and that of smell very acute.

The sense of smell is also utilized in finding mates. The males of the Cecropia, Luna and other moths have the antennae more developed than the females, and this seems to enable them to detect the presence of the other sex. In some moths, as those of the Canker-worms and Tussock moths, the females are entirely wingless on reaching maturity and must consequently be found by the males. In such cases the sense of smell must be the principal factor.

Reviewing the matter up to this point we see plainly that the antennae figure prominently among the senses with insects, and that few insects could do without them, without being crippled in one or more departments of their sensibilities.

*Other Senses Possible.* We have discussed the five senses that are known to us. It is quite within reason that some insects may possess other senses which we cannot comprehend. We can scarcely imagine that the keenest sense of touch, taste, sight, hearing or smell, could guide the honey-bee directly to its hive over miles of woods, fields and meadows. Or (leaving the insect world for the moment) we are at a loss to explain the wonderful flight of the homing pigeons, or the regular migration of our native birds, merely on the basis of the five senses which *we* possess. Some naturalists believe therefore that certain animals at least, have an unerring sense of *direction*, and perhaps also of the *distance* which they have already come. If we can imagine such a sense of direction and distance we can see that it would take the place of the compass and log of the mariner, by means of which he finds his way accurately across trackless seas.

Very much of what we call *Instinct* among insects (and other animals) may be due to the possession of senses other than those with which we are familiar. Just what these senses may be, and how well they may be developed among different animals, are matters of mere conjecture at present. Taking this view, the subject of Instinct takes on a different appearance. It loses its aspect of marvel, but increases in interest.

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# NOTES ON THE PETROGRAPHY OF THE GRANITES OF CHAPEL HILL, NORTH CAROLINA[1]

BY H. N. EATON

Thd village of Chapel Hill, North Carolina, is located upon a gently rounded knob of granite rocks within the "Carolina Metamorphic Slate and Volcanic Belt," bounded upon the east by Triassic sandstone, and on the south and west by sedimentary and pyro-clastic rocks of unknown age. Northward the granite becomes rapidly more basic, reaching a quartz-mica-diorite, or grano-diorite. Rocks resembling true diorites macroscopically are adjacent on the north. Aplite dikes exist everywhere, and a suite of specimens can be easily collected showing a gradation from this binary type to rocks containing biotite and hornblende, The range in color and texture varies from fine grained, white, acid rocks, to those which are dark, medium, and coarse grained.

## PREVIOUS WORK

No previous attempt has been made to study the rocks microscopically. The only place in geological literature where reference has beed made to the area is in a recent publication of the North Carolina Geological Survey.[2] This is merely a brief description of the areal extent and field appearance of the more striking types of granite and diorite in the neighborhood.

1 Presented in outline before the North Carolina Academy of Science, Durham, N. C., May 1, 1909.

2 North Carolina Geological Survey, Bull. No. 2, "The Building and Ornamental Stones of North Carolina," by Watson, Laney, and Merrill, Raleigh, 1906, pp. 55-57.

While the present microscopic work was being done the writer[2] published a description of micropegmatite in one of the binary granites.

The following notes are based on the examination of thin sections only, no chemical analyses having beed made. The numbers refer to specimens in the Geological Laboratory of the University of North Carolida.

### No. 35. Binary Granite.

In handspecimen—fine grained, grayish white, much decomposed; showing only quartz and feldspar.

In thin section—contains quartz, orthoclase, plagioclase, and some epidote.

The crystals aye not all uniform in size, large and small being mixed promiscuously. Plagioclase and quartz occur in the most abundance, and the orthoclase in a relatively insignificant amount.

Maximum albite twinning striations perpendicular to M on the plagioclase gave +9 degrees, thus placing the mixture between oligoclase and andesine.

The orthoclase is in moderately large crystals.

Epidote occurs in several connected lines, probably filling veins.

### No 10-A. Muscovite Granite.

In handspecimen—a medium grained, pink rock, consisting essentially of pink feldspar and quartz.

In thin section—composed of quartz, orthoclase, microcline, plagioclase, muscovite. chlorite, and magnetite. It is mainly a feldspar rock with porphyritic crystals of plagioclase and alkali feldspar, surrounded by a rubble of small quartz and feldspar fragments.

The plagioclase is the most abundant mineral, belonging to the species oligoclase, and displaying albite twinning in very fine striations, also carlsbad twinning. The crystals are short and irregular in outline, and frequently exhibit slight bending as though caused by strain.

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2 This Journal, vol. 24, No. 3, Nov. 1908, pp. 104-105

Microcline is quite abundant; orthoclase, less so.

Graphic intergrowths between plagioclase and the alkali feldspars are common.

Quartz is confined to the fine crystals of the groundmass.

Muscovite occurs in fine shreds bent in long string-like masses, usually near grains of magnetite.

Chlorite was observed in a few small scales.

### No. 10-B. Biotite Granite.

In handspecimen—a medium to fine grained, mottled rock showing on fresh fracture quartz, feldspar, a colored silicate, and a metallic looking mineral.

In thin section—contains quartz, orthoclase, plagioclase, biotite, magnetite, and titanite.

The magnetite is disseminated thickly through the slide in crystals of appreciable size. In one place a relatively large mass surrounds an equally large mass of titanite.

Titanite is quite abundant.

Biotite occurs in short crystals. It is mainly altered to chlorite, and is pleochroic, the range being from straw yellow to grass green.

Plagioclase is of rather sparing occurrence and is near oligoclase in composition, with maximum extincfion angles of 7 and 8 degrees.

Orthoclase occurs in many forms. The crystals are of various sizes, frequently enclosing small particles of plagioclase.

The microcline grating structure can be observed in a number of instances but is indistinct.

Quartz is found well crystallized in large forms.

### No. 18. Biotite Granite.

In handspecimen—a medium to fine grained rock, much decomposed, showing quartz, feldspar, and a dark silicate, probably biotite in an advanced stage of chloritization.

In thin section—contains essential quartz, feldspar and biotite; with accessory magnetite, titanite, and zircon. Epidote appears in a vein, and chlorite as a decomposition product.

Biotite is disseminated sparingly through the slide. It is the only dark colored silicate present, and is universally altered to chlorite.

Oligoclase is quite abundant. The albite twin striations are fine. Carlsbad twinning was noted.

Orthoclase and microcline are abundant, the latter somewhat less so of the two. All of the feldspars are much kaolinized.

Quartz occurs in the usual manner, fflling in the interstices between the earlier formed minerals.

Magnetite occurs sparingly in a few small grains.

Titanite occurs in a few localities in large crystals.

Zircon was observed in one place.

### No. 23. Biotite Granite.

In handspecimen—a medium grained, mottled, pink rock; showing quartz, pink feldspar, and green biotite.

In thin section—contains quartz, orthoclase, microcline, plagioclase, and biotite.

The biotite occurs in small crystals arranged in a number of large clusters. It is of the green variety.

Plagioclase is isolated in a number of small, stout prisms, much kaolinized. Many feldspar crystals, kaolinized beyond recognition. are probably plagioclase.

Orthoclase and microcline are very abundant in square and rectangular prisms.

Quartz occurs in well defined crystals of uniform size.

The uniformity in size of the quartz and feldspar forms is the feature of the slide.

### No. 16. Biotite Granite.

In handspecimen—a coarse grained, mottled rock, with a peculiar blending of dark green and pink on weathered surfaces. There appears to be an abundance of quartz, feldspar (probably orthoclase), and a dark colored silicate arranged in clusters. This last is with difficulty resolved with the hand lens into fine flakes of biotite.

In thin section—composed of quartz, orthoclase, microcline, Plagioclase, biotite, titanite, pyrite, and apatite.

The biotite is the only colored silicate, is green in color, and only sparingly present.

The plagioclase is oligoclase, and not abundant. It occurs in irregularly bounded crystals, much kaolinized.

Microcline is very abundant in relatively large crystals.

Orthoclase covers a total area about equal to the microcline.

Quartz occurs in large irregular masses.

Pyrite is found in several large grains. Incident light shows an individual mass to be composed of an unaltered core of pyrite surrounded by steely hematite, the whole in turn, encased in a rim of hematite.

Titanite occurs in a few scattered crystals.

Apatite occurs in small crystals near the biotite.

### No. 13. Biotite—hornblende granite.

In handspecimen—a coarse grained, mottled, pink rock, much weathered. with much pink feldspar, some quartz, and hornblende.

In thin section—contains magnetite, titanite, biotite, hornblende, plagioclase, and quartz.

Biotite occurs in light green and brown to deep green colors. The brown type is in the smallest crystals and is frequently chloritized. The green variety is found in larger crystals and is less common.

Hornblende occurs in comparatively large amount in large forms. Pleochroism, marked; yellow to deep grass green. Interference, high. Twinning observed.

The plagioclase crystals are large and much kaolinized. Twin striations, very fine. Species, oligoclase.

Orthoclase occurs in large masses, with indistinct boundaries in places.

A few large microcline crystals are present.

### No 8. Hornblende Granite.

In handspecimen medium to coarse grained, mottled rock; showing flesh colored feldspar, quartz, and much hornblende. The specimen is much weathered.

In thin section—composed of essential quartz, orthoclase, microcline, plagioclase, and hornblende; with biotite, magnetite, and apatite as accessories, and chlorite and kaolin as decomposition products.

Hornblende is abundant in irregular crystals and masses of crystal fragments, showing absorption by the later formed quartz and feldspar. Color, green. Strongly pleochroic, grass green to straw yellow. Interference colors, high greens and browns. Some crystals show twinning.

Biotite occurs sparingly. Color, grass green with marked pleochroism.

The plagioclase is oligoclase, occuring in stout idiomorphic crystals, often highly kaolinized.

Orthoclase occurs abundantly in large allotriomorphic crystals.

Microcline is quite abundant, its period of crystallization being between the orthoclase and quartz.

Quartz is very abundant.

Magnetite and apatite are found near the colored silicates.

Chlorite results from biotite decomposition.

### No. 9. Quartz-mica Diorite.

In handspecimen—a medium grained, uniformly dark gray rock, showing an abundance of feldspar and hornblende, and some quartz.

In thin section—composed of quartz, plagioclase, biotite, hornblende, and magnetite.

The hornblende occurs in profusion in long crystals, commonly twinned. Pleochroic; light straw yellow to light green. Interference colors, high. The majority of the crystals are uniform in size, but many smaller ones occur in the groundmass.

Plagioclase, species oligoclase, comprises the larger part of the rock and the crystals are of various sizes. the largest almost amounting to phenocrysts. Smaller crystals are abundant in the groundmass. Albite and carlsbad twinning, universal. Zoning, common. All crystals are idiomorphic, and their boundaries are distinct.

Biotite of the greenish brown variety, is quite common.

Quartz fills in the interstices between the other minerals.

Magnetite is found in a few scattered grains.

The groundmass is composed of smaller crystals of quartz, feldspar, hornblende, and biotite.

University of North Carolina.

# CONDENSATION OF CHLORAL WITH PRIMARY AROMATIC AMINES. III[1]

A. S. WHEELER AND STROUD JORDAN

This research was undertaken, first, to establish the constitution of derivatives of chloral-di-phenamine compounds obtained by the action of bromine and, second, to extend the limited work already done on the condensation of chloral with primary aromatic amines, including a study of their behavior.

## HISTORICAL CONSIDERATIONS

The first real condensation product of an aromatic amine with chloral is tri-chlor-ethylidene-di-phenamine ($C_{14}H_{13}N_2Cl_3$), which is prepared by the action of chloral upon aniline, one molecule of chloral to two molecules of aniline. This reaction was carried out by Schiff and Amato[2] in the year 1875. O. Wallach also prepared this same compound in the same year,[3] independently of the first two workers and he also prepared the condensation products of xylidene and paratoluidine. Later on this reaction was extended to other unsubstituted aromatic amines by A. Eibner,[4] who succeeded in preparing the condensation products of aniline and para-toluidine. Still later, this reaction has been extended to some of the remaining unsubstituted aromatic amines by Wheeler and Jordan[4],[5] who succeeded in making the condensation product of chloral and ortho-toluidine. These reactions have been carried out in a very uniform manner, except for the solvent used, for each product was made by the reaction of one molecule of chloral upon two molecules of the unsubstituted aromatic amine,

[1]This paper forms part of a thesis presented to the Faculty of the University of North Carolina in May 1909 by Stroud Jordan, candidate for the degree of Doctor of Philosophy.

[2] Gazz. chim. ital. I: 376. 1871.

[3]Ber. d. Chem. Ges. 4: 668. 1871.

[4]Ann. Chem. (Liebig) 302: 340. 1898.

[5]Journal American Chemical Society, 30: 141. 1908.

with or without the aid of a solvent. It has been possible to obtain a product which will be very pure, by the action of chloral hydrate with the free amine, as Alexander Eibner did, or by the action of chloral upon the amine, as A. Eibner did and as we have done, or still, by the action of chloral upon the unsubstituted primary aromatic amines in the presence of a solvent, as we have done in the majority of our reactions.

The first substituted primary aromatic amines were condensed with chloral by A. Eibner, when he succeeded in preparing tri-chlor-ethylidene-di-metachlor-phenamine,[1] tri-chlor-ethylidene-di-para-chlor-phenamine,[1] and tri-chlor-ethylidene-di-para-nitro-phenamine[1]. He also extended his study of this condensation reaction to the reaction of chloral and di-chlor-aniline, which he was able to get[1] and to the reaction of chloral and tri-chlor-aniline which he was not able to carry out. Following this work of A. Eibner we have the work of Wheeler and Weller[2], who succeeded in preparing the tri-chlor-ethylidene-di-ortho-phenamine, the work of Wheeler and Miller[3], upon para-brom-aniline and chloral obtaining thus tri--chlor-ethylidene-di-para-brom-phenamine; the work of Wheeler and Dickson[3] on para-anisidine and chloral, and Niementowski and Orzechowski's work[4] on chloral and anthranilic acid. These reactions were all carried out in the same proportions as were used in the unsubstituted primary aromatic amines, that is, two molecules of the substituted primary aromatic amine and one molecule of chloral with or without a solvent.

### NITROGÉN HALIDES

The most thorough study made of nitrogen halides has been made by Chattaway and Orton[5]. They succeeded in getting one hydrogen in the aniline side chain, ($NH_2$), replaced by a halogen when the other hydrogen had been replaced by a negative group,

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1 Ann. Chem. (Liebig), **302**: 340. 1898.
2 Journal American Chemical Society, **24**: 1063. 1902.
3 Journal American Chemical Society, **30**: 136. 1908.
4 Ber. d. Chem. Ges., **28**: 2812. 1895.
5 Journal London Chemical Society, **75**: 1046. 1899.

as CHO or $CH_3CO$. By this means they were able to prepare a number of nitrogen halides, all of which were unstable and tended to isomerize, the halogen going to the para position, if it was unoccupied, and when this position was filled going to the hydrogen ortho to the amino group.

### CONDENSATIONS DESCRIBED IN THIS THESIS

Thirteen new compounds are described in this thesis. They comprise the condensatisn products of chloral with the following primary amines: meta-amino-benzoic acid, para-amino-benzoic acid, 4-nitro-2-toluidine. 2-nitro-4-toluidine, 3-nitro-4-toluidine, meta-chlor-para-toluidine, 5-brom-2-amino-benzoic acid, 4-brom-2-nitraniline, 4-brom-3-nitraniline, para-iodo-aniline, 4-brom-I-napthylamine, and para-amino-aceto-phenone. The behaviour of tri-chlor-aniline and chloral was also studied, not only in high boiling point solvents but also in a sealed tube.

### THEORETICAL CONSIDERATIONS

It will be seen from the results of this work as well as that of previous workers, that chloral does not combine with all primary aromatic amines. It is to be observed further that the condensations are not made with uniform readiness, for Eibner found that when three negative groups are substituted in the benzene ring no condensation takes place and we find that when two negative groups are present, of unlike character, the reaction generally requires the addition of much heat in order that it may take place in the best possible manner. It is necessary to boil the mixture of chloral and the amine for at least one hour and fifteen minutes, in order that the reaction may be completed. We have also observed that when the two negative groups in the benzene ring are similar that the reaction proceeds easier than in the former case but still requires the addition of heat. In the case of one negative group, present in the benzene ring, reaction will take place very slowly and in a very moderate manner, when chloral is mixed with the amine in the presence of some good solvent. When no negative groups are present in the benzene ring, the reaction takes place immediately, with the liberation of a large amount of heat, either in the presence of a solvent or without it. Generally speaking, the condensation products containing the most negative groups are the most stable, and those containing no negative groups the least stable. All these condensation products are broken down on brominating in the presence of glacial acetic acid, splitting off chloral and giving either a bromine derivative of the free amine or an acid salt of the free amine or both. Strong mineral acids will break all these condensation products down into the corresponding salt of the free amine, with the liberation of chloral. In the case of the strongly negative products, alkalies yield an hydroxy derivative. Such a compound is obtained most readily by the action of alcoholic potash. In the case of the condensation products containing no negative groups, in the benzene ring, strong alkalies break them down into the free amine and chloral, only with great difficulty and on prolonged heating, hence they are very stable towards alkalies.

The behaviour of all these condensation products with bromine seem to indicate a regular law for the position of the substituted bromine atom. When they are treated with bromine and it enters the ring it will enter in the position para to the amino group, if this position is not already filled or does not have the neighboring meta position filled with an unlike negative group. When the para position is filled, the bromine will go to the ortho position, if it is not already filled or does not have the neighboring meta position filled with an unlike negative group or the other ortho position filled with an unlike negative group. In the majority of cases, when one position, either meta or ortho, is filled with an unlike negative group, the bromine seems to take the position, whose corresponding position or whose neighboring position, is not filled by an unlike negative group. This substitution does not seem to vary in our work but seems to follow out the general law of isomerization, like the nitrogen halides of Chattaway and Orton.

The melting points and color, also the crystalline form, of some series, like the nitro-toluidines, are very regular, The 2-nitro-4-toluidine, when condensed with chloral, shows lemon-yellow needles, melting at 108-9° C, the 4-nitro-2-toluidine shows golden-yellow needles, melting at 142-3° C while the 3-nitro-4-toluidine shows brownish-yellow needles and melts at 162-3° C. The regular rise in melting point and similiarity in crystalline form seem to fit the majority of cases where like compounds are studied in a series. It is not, however, a general law but will appear in the majority of cases.

## EXPERIMENTAL PART

### *DIVISION I*

#### THE ACTION OF BROMINE AND HCL UPON CERTAIN DI-PHENAMINE COMPOUNDS

(1) The action of Bromine upon Tri-chlor-ethylidene-di-phena--mine

*Action of two molecules of bromine*

The tri-chlor- ethylidene-di-phenamine, made according to A. Eibner's method[1] and purified by successive extractions with hot benzol, leaving behind an insoluble body of which we find no mention in Eibner's work, melting at 190-1°, was dissolved in the least amount of cold glacial acetic acid and bromine was added in the proportion of two molecules of bromine for each molecule of the condensation product. A white crystalline precipitate settled out, on cooling, showing large, scale-like crystals under the microscope and decomposing at 228-30°. It was easily soluble in alcohol, soluble in glacial acetic acid and amyl alcohol and insoluble in benzol, toluol, zylol, gasolene, carbon tetra-chloride and carbon di-sulphide.

An analysis by the Carius method gave the following result:
No. (1) 0.2000 gram of substance gave 0.2980 grams of AgBr.
No. (2) 0.2000 ,, ,, ,, ,, 0.2887 ,, ,, ,,

| Calculated for, | Found, |
|---|---|
| $C_6H_7NBr_2$, | No. (1) 63.40 p. c. |
| 63.24 p. c. of Br. | No. (2) 63.52 p. c. Br. |

This compound was then treated with sodium hydroxide to remove the hydrobrómic acid and thus obtain the free amine, which was found to melt at 63°C. This free amine gave an acet-

[1]Ann. d. Chem. Ges. **302**: 340. 1890

derivative, on boiling with acetic anhydride, which melted at 160-3°. The formation of these two compounds from the free amine proved that it was para-brom aniline and that the original bromine derivative was para-brom aniline-hydro-bromide.

On examining the glacial acetic acid filtrate from the bromine reaction we were able to obtain oily drops of chloroform, when it was neutralized with sodium hydroxide and distilled with steam, showing that the chloral group had been split off by the action of bromine and proving all bromine to be in the ring or attached as the hydro-bromide. The other possibility is substitution in the $NH_2$ group.

*The action of one molecule of bromine*

When one molecule of tri-chlor-ethylidene-di-phenamine was treated with one molecule of bromine, in the same manner as in the previous experiment, the product had the same appearance but it decomposed at 282°. It was soluble in water or alcohol, insoluble in xylene, toluene, benzene, gasolene and carbon tetrachloride. Glacial acetic acid was the most promising crystallizing medium for it was difficultly soluble in the cold solution but readily soluble in the hot.

An analysis of this compound by the Stepanoff method gave the following result:

No. (1) 0.2000 gram of substance gave 0.2167 grams of AgBr.
No. (2) 0.2000 ,, ,, ,, ,, 0.2155 ,, ,, ,,

| Calculated for, | Found, |
|---|---|
| $CH_9NBr$, | No. (1) 46.10 per cent. |
| 45.97 per cent Br. | No. (2) 45.85 ,, ,, |

The bromine derivative was then treated with a sodium hydroxide solution and the hydrobromic acid group taken off, giving back free aniline as the free amine. This was proved to be aniline by making the hydro-chloride and the acetate, each of which gave the proper melting point.

Chloroform was also detected in the glacial acetic acid filtrate from the bromination product.

From the foregoing experiments we would conclude:

*First*, that when tri-chlor-ethylidene-di-phenamine is treated with bromine in a glacial acetic acid solution chloral is split off and a hydrobromide of aniline or the hydrobromide of a brominated aniline is formed, varying with the amount of bromine used in the bromination. And this would suggest that *Secondly*, when any amine condensation product is treated with bromine, the chloral residue will split off and the bromine will enter the ring or attach itself as a molecule of hydrobromic acid, according to the amount of bromine used and the nature of the condensation product.

POSSIBLE FORMATION OF NITROGEN BROMIDES

When the tri-chlor-ethylidene-di-phenamine is acted upon by bromine in glacial acetic acid solution or suspension, two compounds are formed which seem to be aniline hydrobromide and para brom aniline hydrobromide, but which show positive differences from them. They are, however, very unstable and change into aniline hydrobromide and para-brom aniline hydrobromide, on boiling with water, or tend to lose all halogens present and form aniline hydrobromide alone, when acted on by direct sunlight or on allowing the reaction product, obtained from the bromination of the tri-chlor-ethylidene-di-phenamine, to stand for twenty four hours in the original acetic acid solution. after bromination. It would be well to state, just at this point, that we have never been able to repeat all these results which follow, but many have been repeated, which would justify the assumption that a nitrogen bromide has been formed. The first bromine derivative that we shall take up will be the mono-brom derivative.

T*he mono-brom derivative of Tri-chlor-ethylidene-di--phenamine*

In studying the action of one molecule of bromine on one molecule of tri-chlor-ethylidene-di-phenamine, we observed that, in one instance, our product was not aniline hydrobromide, as we formerly supposed, but differed from aniline hydrobromide, both in solubility and in melting point, so we undertook a careful study of its preparation and properties. The method of preparation which was used was the addition of one molecule of bromine, dissolved in glacial acetic acid in the ratio of one cubic centimeter of bromine to nine cubic centimeters of glacial acetic acid, to one molecule of tri-chlor-ethylidene-di-phenamine, dissolved in the least amount of cold glacial acetic acid. After these two were mixed and the temperature kept below fifteen degrees, a white scaly precipitate settled out, melting at 282°, with a deep violet decomposition. The first point taken up was the solubility of this compound as compared to that of aniline hydrobromide. The unknown bromine derivative was found to be only partly soluble in water while the aniline hydrobromide was easily soluble. On boiling the unknown bromine derivative for one and one half hours, with water, a complete solution resulted from which pure aniline hydrobromide crystallized out. The unknown bromine derivative was not very easily soluble in concentrated hydrochloric acid, while the aniline hydrobromide was.

It was shown that the unknown bromine derivative formed aniline hydrobromide on boiling with water by making a solution of such a product alkaline with NaOH and obtaining the free amine, which was proved to be aniline, both by the calcium-hypochlorite and the iso-carbylamine tests.

Our next step was to compare the melting point of the unknown bromine derivative with that of aniline hydrobromide. We found that the unknown bromine derivative melted with a dark violet decomposition at 275-7°, but after boiling with water, it melted at 282°C and gave a brown colored liquid, showing no appreciable decomposition, which was exactly similiar to the original aniline hydrobromide.

The action of sunlight on the unknown bromine derivative and upon aniline hydrobromide showed a distinct difference, both in color and behaviour. The aniline hydrobromide did not change color during a day and a half exposure while the unknown bromine derivative showed a very marked change, turning dark brown and becoming a lumpy mass.

An analysis of this bromine derivative, made from the purest material we had, gave the following result:

No. (1) 0.2000 gram of substance gave 0.2184 grams of AgBr.
No. (2) 0.2000 ,, ,, ,, ,, 0.2167 ,, ,, ,,

| Calculated for | Found |
|---|---|
| $C_6H_7NBr$, | No. (1) 46.46 p. c. |
| 46.51 p. c. of Br. | No. (2) 46.10 p. c. |

This would also be a very good analysis for aniline hydrobromide since the two compounds differ only in the content of hydrogen and the aniline hydrobromide would give 45.97 per cent of bromine.

*Acids* have no apparent effect upon this compound except to form the corresponding salts, as the hydrochloride, hydrobromide and sulphate.

*Alkalies*, either hot or cold, gave the free amine, which was aniline, proving that all the bromine was in the side chain.

*Water* caused a change from the unknown bromine derivative to aniline hydrobromide, on boiling for one and one half hours.

We have not been able to get Chattaway and Orton's reactions for the nitrogen halides, which they claim to be general. Probably this was due to the fact that we are dealing with an unsubstituted nitrogen halide and they were dealing with a substituted one.

*Summary.*

We have shown that we have a body which has all its halogen in the side chain, not as the hydrobromide but as the halide, connected directly to the nitrogen, because, *First*, water does not dissolve our bromine derivative, while aniline hydrobromide is very soluble. *Second*, sunlight does not affect aniline hydrobromide while our compound is decomposed very rapidly. *Third*, on boiling with dilute alkaline solutions the halogen is removed, which would be impossible were the bromine in the benzene ring. *Fourth*, the melting point of aniline hydrobromide is clear and well defined while the unknown bromine derivative decomposes with a violet or purple decomposition at from five to seven degrees lower.

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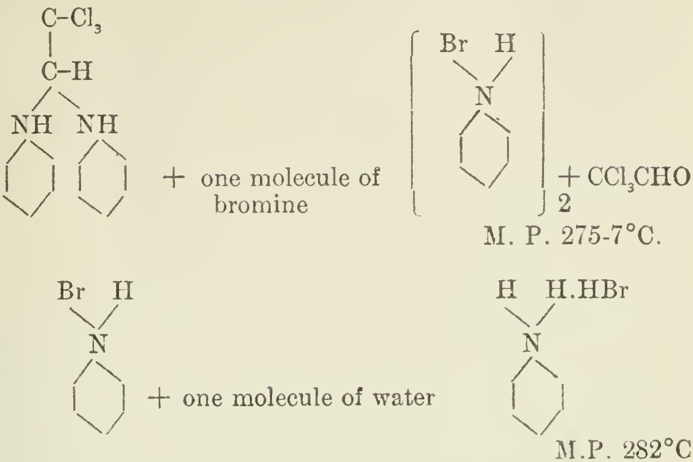
1 Journal London Chemical Society **75**: 1046. 1899.

The reactions for this compound are represented thus:




*The di-brom derivative of Tri-chlor-ethylidene-di-phenamine*

The di-nitrogen bromide is formed when two molecules of bromine react with one molecule of tri-chlor-ethylidene-di-phenamine. This compound was obtained when the pure tri-chlor-ethylidene was suspended in glacial acetic acid and a 10 per cent glacial acetic acid solution of bromine added, little by little, care being taken to keep the temperature as low as fifteen degrees and the whole reacting mass well stirred. A fine white scaly precipitate was obtained, much more insoluble than the original condensation product, melting at 228-35°, with a violet or purple decomposition. This compound was thought to be para-brom aniline hydrobromide, both by its melting point and by its behaviour but a remarkable change was noticed in its preparation, which led us to suspect a di-nitrogen halide.

When one gram of the tri-chlor-ethylidene-di-phenamine was brominated, in the manner described above, and filtered off immediately, a compound melting at 228-235° with a purple decomposition was obtained, but if a similar preparation was allowed to stand for twenty-four hours, before filtering off the glacial acid, a compound was obtained, weighing less by one-third than the former and showing a decomposition point at 282°. The action of this compound, which had been prepared in the former manner and melted at 228-235° was studied in connection with para-brom aniline hydrobromide and a comparison made of their several properties:

*Para-Brom-Aniline Hydrobromide*

Gave a melting point of 225°, with a violet decomposition. Dissolved easily in cold water. When boiled with water it did not change its M. P.

*Unknown Di-Bromide*

Gave a similar melting point and decomposition. Not so easily soluble in cold water. When boiled with water it changed its M. P. to 235°.

The action of sunlight on the two compounds showed that the unknown di-bromide was very unstable in the light. It changed rapidly in color with a simultaneous rise in melting point, while the para-brom aniline was unaffected. The unknown di-bromide changed its melting point from 228-35° to 247-55°, on allowing direct sunlight to act on it for four days, and it was completely changed to aniline hydrobromide on standing for three months in direct sunlight, giving a melting point of 280-2° and an analysis for one bromine atom in the molecule. This compound also gave free aniline on treating it with sodium hydroxide as proved by the iso-carbylamine test. The calcium-hypo-chlorite test also showed the presence of free aniline, thus giving direct proof that the compound was aniline hydrobromide.

The action of water on the para-brom-aniline hydrobromide and on our unknown bromine derivative was markedly different because with the para-brom aniline hydrobromide no change took place while with the unknown bromine derivative some para-brom aniline was formed which came out as an oil. This compound after standing some time will give some aniline hydrobromide and some para-brom aniline hydrobromide, on boiling with water, showing that originally all bromine was attached to the nitrogen and that it tends to break off on exposure to direct sunlight. On boiling this bromine derivative, which had been exposed to direct sunlight, aniline hydrobromide is formed while in the case of the unexposed bromine derivative isomerization takes place and para-brom aniline hydrobromide is formed.

On analysis one sample of the di-bromide showed the following remarkable result:

0.2000 gram of di-bromide gave 0.2914 grams of AgBr.

| Calculated for | Found |
|---|---|
| $C_9H_5NBr_2$ | 62.00 per cent. |
| 63.74 per cent of bromine. | |

This analysis was made by boiling a sample of the di-bromide for fifteen minutes in a ten per cent sodium hydroxide solution, neutralizing with nitric acid and adding enough more to make the solution react strongly acid to litmus and then titrating the solution with $AgNO_3$, titrating the excess of $AgNO_3$ with $NH_4SCN$, according to Volhard's method. We were never able to repeat this work. Our results on different samples have ranged from 46.10 per cent of Br to 70.89 per cent of Br for the halogen content. It will be noticed that these figures run all the way from a mono-halogen derivative to a tri-halogen derivative, and that all are decomposed by a weak alkaline solution.

## SUMMARY

From the foregoing results we would conclude that we have a nitrogen halide, in which the nitrogen of the amine is joined to two bromine atoms, because:

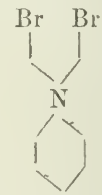
*First*, when our di-brom derivative, formed by the action of two molecules of bromine on one molecule of tri-chlor-ethylidene-di-phenamine, was allowed to stand for twenty-four hours in the original brominated solution before filtering, we found a rise in melting point from 228-35° to 282°, and a compound formed which was proved to be aniline hydrobromide, both by its melting point and by the free amine which was aniline.

*Second*, when our unknown di-bromide is exposed to light for three months, it changes melting point from 228°-35° to 282° and a compound is formed which was proven to be aniline hydrobromide. This could not happen in the case of para-brom aniline hydrobromide.

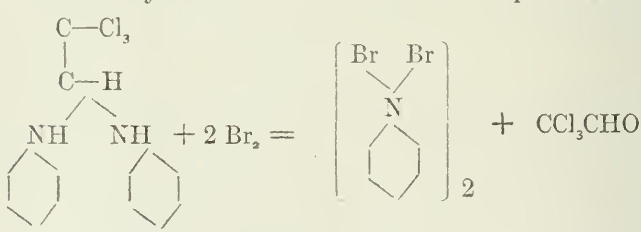
*Third*, On boiling with a dilute solution of an alkali, a per cent of bromine is obtained which would indicate that two bromine atoms were attached to the nitrogen for we find 62.00 per cent of bromine and the theory for two bromine atoms in the molecule would be 63.74 per cent of bromine. This would indicate that we have both of the bromine atoms attached to the nitrogen, because dilute alkalies will not take the bromine out of the benzene ring.

*Fourth*. Para-brom aniline hydrobromide can never change into aniline hydrobromide, by a simple exposure to sunlight, while our bromine derivative does. Para-brom aniline hydrobromide cannot give an analysis for two bromine atoms, on boiling with water or dilute alkali, while the unknown di-bromide does.

The formula for our di-bromide would then be:




and the reactions by which it is made would be represented thus:




(2) The Action of Bromine on Tri-chlor-ethylidene-di-para-nitro-Phenamine.

The object of this research was to establish the constitution of the compound obtained by brominating tri-chlor-ethylidene-di-para-nitro-phenamine, in a glacial acetic acid solution. This reaction was first carried out by A. S. Wheeler in this laboratory, in 1903 and the first general study of it was made by the author of this thesis, in the college year 1904-05. The study assumed some importance because all the condensation products of chloral with primary aromatic amines reacted smoothly with bromine in glacial acetic acid. At first we thought that we had the condensation product with the hydrogen atom in the chloral residue substituted with bromine, although no decomposition product could be obtained which would prove this. Work several years later on the bromination of tri-chlor-ethylidene-di-phenamine threw a clear light on this compound and analogous ones. It was found not to contain any chlorine at all, by a displacement of all chlorine in the compound by bromine and weighing the precipitate as silver bromide. The chloral group is therefore split off in the bromination-as shown by making the filtrate from the reaction product alkaline and distilling, chloroform separating out in globules in the distillate. The bromine derivative is 2-6-di-brom-4-nitranilin with a melting point of 202-3°, that given for the above compound in Beilstein being 202.5°. The formula then is $C_6H_5N_2O_2Br_2$, with a theoretical percentage of bromine of 54.05 per cent. Our analysis by the Carius method showed the following result:

0.1000 gram of the bromine derivative gave 0.1286 grams AgBr.

| Calculated for | Found |
|---|---|
| $C_6H_3C_2N_2Br_2$ | 53.95 per cent of bromine. |
| 54.05 per cent of bromine. | |

These figures would also indicate a compound like our condensation product in which one hydrogen had been substituted for by one bromine atom, giving approximately the same theoretical per cent.

The solubility of this bromine derivative was found to be as follows: easily soluble in alcohol, hot or cold; difficultly soluble cold, easily soluble in hot glacial acetic acid; easily soluble in cold or hot acetone; insoluble in gasolene, xylene, toluene, or benzole.

*The Action of HCl*

When this bromine derivative was treated with concentrated hydrochloric acid no corresponding hydrochloride was formed because of the ease with which it was decomposed in any solution containing water, so we dissolved the 2-6-di-brom-4-nitranilin in cold acetone and passed in dry hydrochloric acid gas until a beautiful scaly, white precipitate came down, very similar in crystals line form to acet-anilide. This hydrochloride was easily decomposed by the addition of water, liberating hydrochloric acid and regenerating the original di-brom-nitranilin. An analysis of this hydrochloride, by the Stepanoff method, showed the presence of one chlorine and two bromine atoms.

*The Action of HBr*

The hydrobromide of 2-6-di-brom-4-nitranilin was made by the addition of bromine to a hot solution of the di-brom nitranilin in glacial acetic acid. The acid derivative showed the same crystalline form and the same behavior towards water as the hydrochloride. It gave an analysis by the Stepanoff method which showed the correct percentage for three bromine atoms. This compound was very unstable, even in the air, for on exposing it to the air for a short time all the hydrobromic acid would be lost.

*Chlorination of Tri-chlor-ethylidene-di-para-nitro-phenamine*

On treating the tri-chlor-ethylidene-di-para-nitro-phenamine with chlorine, the 2,6-di-chlor-4-nitranilin was obtained, melting at 188°. It was a golden yellow compound crystalling out in long, prismatic needles.

(3) The action of bromine upon Tri-chlor-ethylidene-di-para-Tolamine

Para-toluidine and chloral were brought together in the proper proportions with benzene as a solvent.[1] The mixture was warmed slightly and the excess of benzene wrs driven off, allowing the tolamine to crystallize out. It became a thick paste in a veiy shor time and the mother-liquor, mechanically extracted, was dried out on an unglazed porcelain plate. The solid, obtained thus, was extracted several times with cold alcohol, by pouring alcohol over the product on a Buchner funnel and a pretty white, crystalline body was obtained. The melting point of this product was 115°, which identified it as A. Eibner's condensation product, described in the Annallen.

Ten grams of this condensation product were dissolved in the least amount of glacial acetic acid and two atoms of bromine were added very slowly, keeping the mass well stirred. The product obtained thus was filtered off and dried and found to represent an 85 per cent yield of para-toluidine hydrobromide. It was proved

[1]American Chemical Journal 22, 266. 1899.

to be para-toluidine hydrobromide by its decomposition point of 308-11°, its solubilities and its behaviour towards acids and alkalies. It was decomposed by water, made slightly alkaline with sodium hydroxide, giving free para-toluidine which melted at 48°. The free amine was also distilled and found to boil at 198-9°, which is the correct boiling point for para-toluidine.

Ten grams of the condensation product were then treated with four atoms of bromine in the manner just described. The result was a 95 per cent yield of the bromination product. This product was then treated with sodium hydroxide and shaken out with ether which gave ten grams of the free amine. On distilling this product, eight grams came over at 199-210°, five-tenths of a gram came over from 210-50° and the residue, left in the flask decomposed. The first fraction gave crystals on standing, which melted at 48°, showing that the majority of the product was para-toluidine. It was further identified by its hydrochloride and hydrobromide. The fraction above 210° gave needle like crystals, melting at 72-3° which must be 3,5-di-brom-4-toluidine. Another indication observed was its non-combining power with acids.

The mother-liquor after crystallization of the fraction 199-210°, and the fraction 210-50°. was an oil which would not crystallize, at room temperature, so the hydrobromide and the hydrochloride were made from this. The hydrochloride derivative decomposed at 212-22°, while the hydrobromide derivative gave a decomposition point at 252-5°, showing this oil to be 3-brom-4-toluidine, the bromine being ortho to the amino-group. The melting point of this compound should be 26° and it was found to be so.

This did not give us a preparation method for the brom-toluidine as it gave too much of a mixture.

### (4) The Action of Bromine on Tri-chlor-ethylidene-di-ortho-Tolamine.

Ortho-toluidiné and chloral were brought together in the proper proportions to make the condensation product, according to the method of Wheeler and Jordan[1]. This was carried out by the addition of four parts of ortho-toluidine to three parts of chloral and then warming the mixture on a water bath for a short time.

The oil obtained in this manner was allowed to stand for a day to crystallize out. A hard solid mass was the result. We found that alcohol was really a better solvent than ether, which was used in the former method for recrystallizing the product. After two crystallizations from alcohol, the condensation product was found to be pure and gave a sharp melting point at 80°.

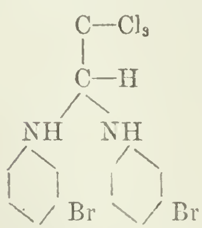
To this condensation product two atoms of bromine were added, or approximately one gram of the condensation product to 0.50 gram of bromine. This reaction was carried out in a glacial acetic acid solution and a very nearly 75 per cent yield was obtained. The resulting bromination product melted with a decomposition at 268°, but after recrystallization it came out in pearly, shining plates, melting with decomposition at 280°. This product was proven to be the 5-brom-2-toluidine-hydrobromide, both by its melting point and the melting point of its nitrate. which melted at 180-3°. The free amine melted at 58-60°.

This did not give a satisfactory method for the preparation of 5-brom-2-toluidine, as some ortho-toluidine was left unchanged and a little of the di-brom-toluidine was also formed, very similar to the action of bromine on the para-toluidine.

## *DIVISION II*

### THE CONDENSATION OF SOME PRIMARY AROMATIC AMINES WITH CHLORAL

Tri-chlor-ethylidene-di-meta-brom-phenamine




Molecular weight, *483*.

Melting point, 115-16°.

For this preparation twenty grams of meta brom-aniline were dissolved in 50 cc. of benzol and to this mixture were added nine grams of freshly distilled chloral. The reaction took place at once, with the liberation of a small amount of heat, giving a theoretical yield of the crude product. This crude product was composed of two parts, a small by-product, which melted at 215-20° and the condensation product. These two compounds were separated by extracting the crude product with benzol thereby dissolving the condensation product and leaving the by-product undissolved. The benzole extract, which contained all the tri-chlor-ethylidene-di-meta-brom-phenamine in solution, was evaporated down over a steam bath to a sirupy constituency. Upon cooling and scratching the sirupy residue with a glass rod it yielded a substance melting at 98-101°, which crystallized from carbon tetrachloride in beautiful white needle-like crystals. After two recrystallizations from carbon tetra-chloride, the meltiag point was raised to 115-16°. The crystalline form of this compound, when seen under the microscope, appeared to be rhombic bi-pyramids, some crystals truncated on the apeces, others regular. and still others having one set of faces much larger than the other set.

*Water* had no effect on this condensation product, either when cold or when boiling hot. *Hydrochloric acid* gave the salt of the original meta-brom-aniline, while bromine gave the hydrobromide of the original meta-brom-aniline.

An analysis of this compound gave the following results, by the Carius method;

No. (1) 0.2000 gram of substance gave 0.1817 grams of AgCl and 0.1596 grams of AgBr.

No. (2) 0.2000 gram of substance gave 0.1802 grams of AgCl and 0.1581 grams of AgBr.

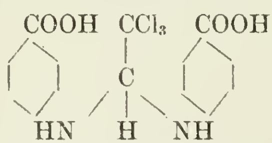
| Calculated for | | Found |
|---|---|---|
| $C_{14}H_{11}N_2Br_2Cl_3$ | (1) | 56.38 per cent, Total |
| | | 22.43 per cent Cl. 33.95 per cent Br. |
| 56.24 per cent of Br. and Cl. | (2) | 55.89 per cent, Total |
| | | 22.25 per cent Cl. 33.63 per cent Br. |

### ACTION OF BROMINE

In making a careful study of the action of bromine on tri-chlor-ethylidene-di-meta-brom-phenamine, the method of Wheeler and Valentine was followed[1] for the separation of the several bromine derivatives. We hoped to obtain a method for the production of

3,4-di-brom-aniline which would give a better yield than the methods used at present. For this work 29.7 grams of the condensation product, which melted at 115-16°, were dissolved in the least possible amount of glacial acetic acid at room temperature. To this solution were added twenty grams of bromine also dissolved in glacial acetic acid, in the ration of one cubic centimeter of bromine to nine cubic centimeters of glacial acetic acid. A beautiful, scaly, white precipitate was obtained, which was filtered off and which weighed twenty grams. To the filtrate from this precipitate water was added and the tetra-brom aniline was precipitated. It weighed 2.6 grams. The bromine precipitate was treated with water and the tri-brom aniline was left undissolved while the di-brom aniline and brom-aniline hydrobromides were dissolved. This tri-brom aniline weighed 5.0 grams and the di-brom aniline weighed 8.0 grams, while only a trace of the original meta-brom aniline was obtained. We concluded from these results that this method possessed no advantage over the direct bromination of meta-brom aniline and so do not recommend it as a preparation method for 3, 4-di-brom aniline.

(2) Tri-chlor-ethylidene-di-para-amino-benzoic Acid




Molecular weight, *403.4*.

Melting point, 215-20°.

For a study of the action of para-amino-benzoic acid with chloral, we used two molecules of the acid, melting at 186-7°, to one molecule of chloral or about 10 grams of the acid to 5.5 grams of chloral. The aminobenzoic acid was suspended in 100 cc. of benzol and the chloral was added to this suspension after which the whole mass was warmed up on a water bath and then boiled for three hours under a reflux condenser. Most of the benzol was then evaporated off and the and the mixture was filtered while hot. This gave a compound which began to char at 186° and turned black at 220°, but which after recrystalling from glacial acetfc acid, melted at 215-220° with much decomposition. This was as pure as it was able to obtain the condensation product for further recrystallizations did not raise the melting point. The crystalline form of this compound was not very well defined, the crystals occurring in colorless masses.

This compound was easily soluble in ethyl or methyl alcohol, difficultly soluble in glacial acetic acid and apparently insoluble in benzene, tolueme, xylene, carbon tetra-chloride and carbon di-sulphide.

The yield was 87.74 per cent of the theoretical or 13.6 grams of the condensation product from 10.0 grams of the para-amino-benzoic acid and 5.5 grams of chloral.

On analysis, this compound gave the following results by the Stepanoff method:

No. (1) 0.2000 gram of substance gave 0.05266 grams of chlorine.

No. (2) 0.2000 gram of substance gave 0.05517 grams of chlorine.

| Calculated for | | Found |
|---|---|---|
| $C_{16}H_{13}O_4N_2Cl_3$ | (1) | 26.33 per cent Cl. |
| 26.37 per cent Cl. | (2) | 27.58 per cent Cl. |

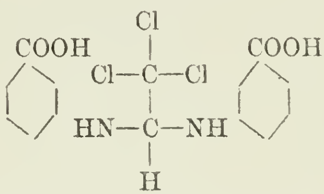
THE ACTION OF BROMINE

For a study of the action of bromine upon this condensation product we used 11.0 grams of the condensation product, 87 grams of bromine and mixed them together in 100 cc. of glacial acetic acid. Action was allowed to take place in the cold and the precipitate was filtered off. This precipitate was the hydrobromide of 3, 5-di-brom-para-aminobenzoic acid, as shown by its melting point, after treatment with water, which was 292-3° decomposing to a black mass. The action of water was to break off the hydrobromic acid and liberate the free amine. This free amine, when diazotized by the action of $NaNO_2$ and strong sulphuric acid in boiling alcohol solution, gave 3, 5-di-brom-benzoic acid, melting at 213-15°. This fully identified the bromine derivative.

When the condensation product is boiled with water no apparent change is noticed either in melting point or in general behavior.

When the condensation product is treated with concentrated hydrochloric acid the corresponding para-aminobenzoic acid hydrochloride is formed, which when treated with sodium hydroxide and neutralized, gave the alkaline salt of para-amino-benzoic acid which could be acidified with acetic acid and precipitated with water, giving para-aminobenzoic acid.

Tri-chlor-ethylidene-di-meta-aminobenzoic Acid.



Molecular weight, *403.4*

Melting point, 240°.

For this preparation 10.0 grams of the meta-aminobenzoic acid were used, melting at 174°. This acid was dissolved in 100 cc. of benzol and to it were added 5.5 grams of freshly distilled chloral. This solution was boiled for one and one-half hours over a steam bath and a crude product of theoretical yield was obtained, after the excess of benzol had been evaporated off. The crude product was extracted for four or five successive times and the several extracts were mixed and allowed to crystallize out very slowly. This gave a white, crystalline mass which was soluble in benzol, acetone, amyl alcohol, glacial acetic acid and alcohol, insoluble in xylene, carbon-tetrachloride, ligroin, and cold or hot chloroform, and difficulty soluble in ether.

An analysis was made from 0.2000 gram of this sample which melted at 240° with a violet black decomposition and which had been crystallized from benzol and heated in an air bath for one and one-half hours to drive off the benzol. This analysis was carried out by the Stepanoff method and gave the following results for chlorine:

(1) 0.2000 gram of substance gave 0.2146 grams of AgCl.

(2) 0.2000 gram of substance gave 0.2104 grams of AgCl.

| Calculated for | Found |
|---|---|
| $C_{16}H_{13}O_4N_2Cl_3$ | (1) 26.50 per cent Cl. |
| 26.37 per cent Chlorine. | (2) 25.93 per cent Cl. |

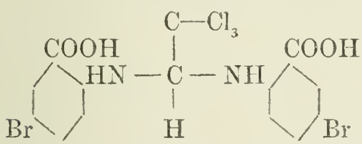
The crystalline form of this compound resembled that of the para-amino-benzoic acid condensation product in that it was composed of colorless crystal masses showing no definite form under the microscope.

THE ACTION OF BROMINE

The condensation product was then treated with bromine by dissolving 5.5 grams in 100cc. of glacial aeetic acid and adding 4.3 grams of bromine, little by little. The yield from this was 7.0 grams of the bromine derivative, melting with a dark purple decomposition at 279-82°. This bromine body was boiled with water and a solution thus obtained. Free hydrobromic acid in the solution showed the product to be a salt. The aqueous solution on extraction with ether yielded a substance melting from 215-16°, which is the melting point of 5-brom-3-aminobenzoic acid. The proof was made more certain by the preparation of the sulphate and the hydrochloride.

When the condensation product is treated with concentrated hydrochloric acid, the acid salt of the free meta-aminobenzoic acid is formed, giving the free amine on boiling with a dilute alkaline solution and extracting with ether. This compound melts at 174°. Boiling water has no apparent effect on this condensation product.

Tri-chlor-ethylidene-di-5-brom-2-aminobenzoic Acid




Molecular weight, *561*.

Melting point, 174-5°.

For this preparation the 5-brom-2-aminobenzoic acid was made by brominating anthranilic acid in glacial acetic acid solution and decomposing the hydrobromide formed by boiling with water. It was purified by recrystallization from hot water according to the method of Wheeler and Oates.[1] Five grams of the 5-brom-2-aminobenzoic acid were dissolved in 100cc. of toluene and 1.8 grams of chloral were added. This solution was boiled for one and one half hours under a reflux condenser and then allowed to cool slowly. A white, crystalline precipitate, consisting of clusters of needle-like prisms settled out, melting at 174-5°. Analysis by the Stepanoff method gave the following results;

| Calculated for | Found |
|---|---|
| $C_{16}H_{11}O_4N_2Br_2Cl_3$ | (1) 28.01 per cent Br. |
| | 18.62 per cent Cl. |
| 28.52 per cent Br. 18.95 per cent Cl. | (2) 28.63 per cent Br. |
| | 18.96 per cent Cl. |

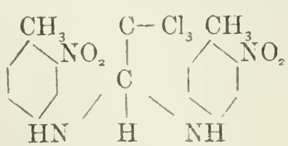
This compound was soluble in toluene, benzene, glacial acetic acid and alcohol. It was decomposed by water and all solvents containing water. When it is boiled with water it breaks down into chloral and 5-brom-2-aminobenzoic acid.

On treating this condensation product with concentrated hydrochloric acid, an effervescence is noticed, accompanied by the liberation of chloral and the reforming of 5-brom-2-aminobenzoic acid which melts at 216°. No hydrochloride of this compound is formed in aqueous solution, which is true of the original 5-brom-2-aminobenzoic acid.

ACTION OF BROMINE

When this product is brominated in a glacial acetic acid solution adding bromine until a permanent red color is obtained, a white, crystalline precipitate is formed, which melts at 234° decomposing to a black mass. On boiling this bromine derivative with water a solution is obtained, showing a blue fluorescence which is characteristic of 5-brom-2-aminobenzoic acid in water. On allowing this hot solution to crystallize out, yellowish-white needles are obtained which melt at 213-15°. A residue is always obtained which is insoluble in water, when the bromination product is boiled with water, melting at 221-3°. This is very probably one of the di-brom anthranilic acids.

Tri-chlor-ethylidene-di-ortho-nitro-para-Tolamine




Molecular weight, *433.35*.

Melting point, 108-9°.

For this preparation five grams of 2-nitro-4-toluidine were used, melting at 77.5°. This compound was dissolved in 100cc. of toluene and 2.6 grams of freshly distilled chloral were added, after which the mixture was boiled for one and one-half hours. After boiling, the solution was cooled down and enough gasolene was added to precipitate out the compound, which had been formed in the reaction, giving an oil which solidified on standing on a moderately warm water bath for a half hour. This compound was soluble in alcohol, benzene, toluene, acetone and glacial acetic acid, being insoluble in gasolene and only slightly soluble in ether. After two crystallizations from a mixture of toluene and gasolene, a melting point of 108-9° was obtained, the substance melting down to a clear liquid.

An analysis of this compound was made by the Carius method and the following results were obtained:

No. (1) 0.1000 gram of substance gave 0.1003 grams of AgCl.
No. (2) 0.1000 gram of substance gave 0.1013 grams of AgCl.

| Calculated for | Found |
|---|---|
| $C_{16}H_{15}O_4N_4Cl_3$. | (1) 24.77 per cent Cl. |
| 24.52 per cent Chlorine. | (2) 25.02 per cent Cl. |

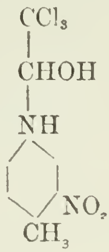
This compound gave on boiling with concentrated hydrochloric acid, a clear solution which on cooling gave long silvery-white needles, melting at 230-40° with a blackish decomposition. A sample of the pure 2-nitro-4-toluidine was converted into the hydrochloride by boiling with concentrated hydrochloric acid and it gave the same silvery-white needles melting at the same point with the same blackish decomposition. When the unknown hydrochloride was treated with ammonia and the free amine precipitated out it melted at 78-80°, showing that hydrochloric acid decomposed the condensation product, liberating chloral and forming the hydrochloride of 2-nitro-4-toluidine.

When this condensation product was boiled with water no change was produced in the melting point or crystalline form.

### ACTION OF BROMINE

0.20 gram of this condensation product was dissolved in the least amount of acetic acid, in the cold, and to this bromine was added also dissolved in glacial acetic acid. This gave a white, scaly, crystalline precipitate which melted at 240-50°, with a blackish decomposition. Some of the 2-nitro-4-toluidine was then taken and treated with hydrobromic acid, forming the hydrobromide, which gave the same crystalline form and the same decomposition point at 240-50° thus proving the unknown bromine derivative to be the hydrobromide of 2-nitro-4-toluidine. The free amine, formed by neutralizing the hydrobromide with ammonia, gave a melting point of 75-80°, again proving the unknown bromine derivative to be the 2-nitro-4-toluidine hydrobromide. The bromine had liberated chloral and formed the bromide of the free amine with which the chloral had been condensed, no bromine entering the ring.

The Addition Product of 2-nitro-4-Toluidine and Chloral




Molecular weight, *299.35*.

Melting point, 187-8°.

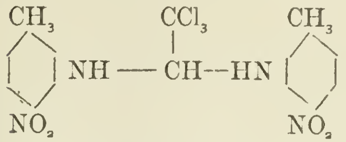
When the pure 2-nitro-4-toluidine was treated with chloral in the proportion of one molecule of 2-nitro-4-toluidine to one molecule of chloral, an addition product was obtained. For this preparation, 2.5 grams of the 2-nitro-4-toluidine were used. This was dissolved in benzol and two and one-half grams of chloral were added after which it was boiled for one hour over a steam bath, and then most of the benzol was evaporated off. On cooling the concentrated benzol solution, a fine crop of beautiful yellow needles separated out, melting at 147-8° but which after dissolving in benzol and precipitating out with gasolene, gave a melting point of 187-8° This compound was easily soluble in alcohol, benzene, glacial acetic acid and acetone, but it was insoluble in gasolene or xylene.

An analysis of this compound was made by the Carius method and gave the following results:

No. (1) 0.1000 gram of substance gave 0.1451 grams of AgCl.
No. (2) 0.1000 gram of substance gave 0.1457 grams of AgCl.

| Calculated for | Found |
|---|---|
| $C_9H_9O_3N_2Cl_3$ | (1) 35.91 per cent Cl. |
| 35.54 per cent Cl. | (2) 35.98 per cent Cl. |

Tri-chlor-ethylidene-di-para-nitro-ortho-Tolamine



Molecular Weight, *433.35*.
Melting point, 142°.

For this preparation 2.5 grams of 4-nitro-2-toluidine, melting at 109°, were dissolved in 50cc of benzol and then 1.5 grams of freshly distilled chloral were added. This solution was boiled for one and one-half hours over a steam bath, and a crude product of very nearly theoretical yield was obtained, after evaporating off the excess of benzol. This crude product was then dissolved in boiling benzol and filtered, giving an insoluble substance which melted at 215-30° with a blackish decomposition, and a filtrate which contained all the tri-chlor-ethylidene-di-para-nitro-ortho-tolamine. When this solution of the condensation product was evaporated down and the pure compound allowed to crystallize out, an 85 per cent yield was obtained which gave a melting point of 142-3°, melting down to a clear liquid. It was readily soluble in carbon tetra-chloride, benzol and glacial acetic acid but not so easily soluble in alcohol. Glacial acetic acid was found to be the best crystallizing medium, as it dissolved a large quantity while hot and on cooling a large amount of the compound crystallized out in long golden-yellow needles.

An analysis of this compound by the Carius method gave the following results:

0.2000 gram of substance gave 0.1961 grams of AgCl.

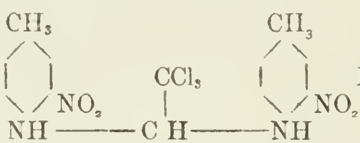
| Calculated for $C_{16}H_{15}O_4N_4Cl_3$, | Found |
|---|---|
| 24.52 per cent Chlorine. | 24.26 per cent Chlorine. |

## ACTION OF BROMINE

This condensation product, dissolved in cold glacial acetic acid, was treated with bromine also in glacial acetic acid solution (1-10), using 5.0 grams of the condensation product and enough bromine to produce a red color. A faint yellow, crystalline precipitate was obtained which melted, when recrystallized from glacial acetic acid, at 215°, giving a blackish decomposition. When this bromine derivative was boiled with a 10 per cent solution of sodium hydroxide, it gave the free amine, which began to soften at 103° and melted down at 110°, proving that we had the hydrobromide of 4-nitro-2-toluidine formed and that when it was treated with sodium hydroxide the hydrobromic acid group was split off and the 4-nitro-2-toluidine was regenerated. No bromine entered the benzene nucleus.

When the condensation product was heated on a water bath with concentrated hydrochloric acid, it gave the corresponding hydrochloride. which when treated with ammonia, precipitated out the free amine, melting at 107-9°. This proved that the hydrochloride was the hydrochloride of 4-nitro-2-toluidine. The condensation product is stable in boiling water.

Tri-chlor-ethylidene-di-meta-nitro-para-Tolamine




Molecular Weight, *433.35.*
Melting point, 165-6°.

For this preparation 2.5 grams of the freshly prepared 3-nitro-4-toluidine, melting at 114-16°, were used. This compound was dissolved in 100cc. of toluene and to this solution were added 1.5 grams of freshly distilled chloral, after which the whole solution was heated for three hours over steam. A brownish-yellow mass of needles settling out on cooling which melted at 162-3°, but which after recrystallization from toluene, melted at 165-7°. This compound was easily soluble in toluene, benzene, gasolene, alcohol and glacial acetic acid.

An analysis by the Carius method showed the following result: 0.0644 grams of substance gave 0.0646 grams of AgCl.

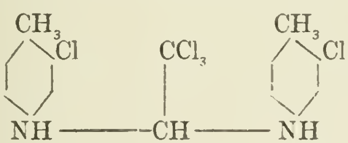
| Calculated for $C_{16}H_{15}O_4N_4Cl_3$ | Found |
| --- | --- |
| 24.52 per cent Chlorine. | 24.77 per cent Chlorine. |

On treating this condensation product with concentrated hydrochloric acid and boiling, a dirty-white, crystalline precipitate came out on allowing it to cool. This hydrochloride decomposed at 187-9°, with a black decomposition. On treating this hydrochloride with ammonia, the free amine was obtained in a very pure state, but which on recrystallization from alcohol gave a melting point of 114-16°, thus proving it to be the 3-nitro-4-toluidine hydrochloride. It will be noticed here that this hydrochloride is much more unstable than those formed from the other nitro toluidines, because it is a meta-nitro compound, which contains the nitro group in the most unstable position.

On boiling the condensation product with water it changed into a black, gummy mass and seemed to decompose to a large extent, for the melting point was lowered about twenty-five degrees.

On treating this condensation product with bromine, a brownish-white crystalline precipitate was formed, melting at 225-7°, with a blackish decomposition. When this bromine derivative is treated with sodium hydroxide, the free amine is liberated and precipitated out of solution, melting at 110-16°, thus proving it to be the hydrobromide of 3-nitro-4-toluidine.

Tri-chlor-ethylidene-di-meta-chlor-para-Tolamine




Molecular Weight, *412.25*.
Melting point, 110°.

The meta-chlor-para-toluidine, used in this preparation was made by chlorinating para-acettoluide according to the method of Wroblewski[1].

Five grams of the pure meta-chlor-para-toluidine, boiling at 218°, were dissolved in 100cc. of benzol and 3.5 grams of chloral were added. This solution was boiled for one hour and fifteen minutes and on cooling there separated out long, silvery-white needles melting at 181°. The filtrate from this was evaporated down to sirupy consistency over steam and allowed to crystallize out. This gave fine white needles, shorter than those of the other

[1]Ann. 168: 196.

crop and melting at 110°. The first crop of crystals proved to be the addition product and will be taken up later in this paper, while the second crop of crystals proved to be the condensation product.

A sample of the second crop of crystals, melting at 110°, was dissolved in 95 per cent alcohol and filtered off from any of the addition product that might be present, since the addition product was not soluble in alcohol while cold. By this means a pure sample was obtained, melting sharply at 110°. An analysis by the Carius method gave the following result:

0.1000 gram of substance gave 0.1745 grams of AgCl.

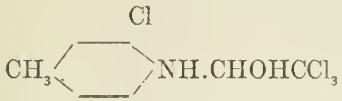
| Calculated for $C_{16}H_{15}N_2Cl_5$ | Found |
| --- | --- |
| 42.96 per cent Chlorine. | 43.10 per cent Chlorine. |

This compound was easily soluble in alcohol, benzol, toluene, xylene, ether and glacial acetic acid. It was much more soluble in alcohol than the addition product and by this means they were separated from each other.

When this condensation product was treated with concentrated hydrochloric acid and the solution heated over a steam bath until the excess of hydrochloric acid was driven off, a white, crystalline precipitate was obtained, melting to a black liquid at 230-35°, a majority of the substance in the melting point tube subliming. This compound was the hydrochloride of meta-chlor-para-toluidine, for when this compound was treated wirh ammonia and the hydrochloric acid group split off, an oil was obtained melting at from 20 to 23° and giving the same reactions as the original meta-chlor-para toluidine.

When the condensation product was dissolved in cold glacial acetic acid and treated with bromine, also in glacial acetic acid solution, (1-10), a white crystalline precipitate was obtained, crystallizing out in long colorless prisms. This bromine compound gave the melting point 78-80°. On treating this bromine derivative with ammonia, no change took place in the melting point, so it was concluded that the product was a bromine derivative of meta-chlor-para-toluidine which did not form a hydrobromide, but had substituted bromine in the ring. No compound which corresponded to this was found in the literature. It is probably the ortho-brom-meta-chlor-para-toluidine.

The addition product of chloral and meta-chlor-para-Toluidine




Molecular Weight, *288.8*
Melting point, 182°.

The first crop of crystals from the condensation of meta-chlor-para-toluidine, melting at 182°, was washed thoroughly with alcohol to remove all of the condensation product that might be present. Then a sharp melting point of 182-3° was obtained. A sample of this product was analyzed by the Stepanoff method and gave the following result:

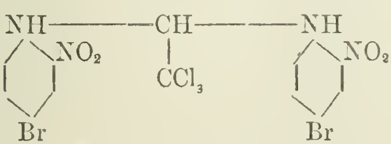
0.1000 gram of substance gave 0.2001 grams of AgCl.

| Calculated for $C_9H_9ONCl_4$ | Found |
|---|---|
| 49.10 per cent Cl. | 49.42 per cent Cl. |

This compound was only slightly soluble in alcohol, easily soluble in ether, benzol, gasolene, toluene, xylene and glacial acetic acid. It will be noted that it was much less soluble in cold alcohol than the condensation product and was purified by this method.

When this compound was treated with concentrated hydrochloric acid and bromine, the two reactions were similar to those for the condensation product, in that chloral was liberated in each case and the corresponding hydrochloride and the substituted bromine derivative were obtained.

Tri-chlor-ethylidene-di-para-brom-ortho-nitro-Phenamine




Molecular Weight, *563.35*.
Melting point, 190-1°.

The 4-brom-2-nitraniline, for this preparation, was made by treating para-brom acetanilide with a mixture of concentrated sulphuric and nitric acids, according to the method of Hubner.[1]

Five grams of the pure 4-brom-2-nitraniline, melting at 110°, were dissolved in 100cc of toluene and about 6.5 grams of chloral were added, or about four times the amount of chloral required to make the condensation product. This solution was boiled for six hours, after which it was allowed to cool. Long, lemon-yellow needles separated out, melting at 232-3°, with a brownish-black decomposition. These crystals reacted with strong sodium hydroxide, forming a red compound, probably the hydroxy body, similar to the one made by Wheeler and Glenn.[2] This compound, melting at 232-3°, was very probably the addition product and was not investigated.

The filtrate from the lemon-yellow needles, which melted at 232-3°, was evaporated down to a sirupy consistency and a crop of smaller lemon-yellow crystals were obtained, melting at 190-1° and showing needle-like prisms under the microscope. This product was crystallized from toluene for two successive times but no change in melting point was obtained. This compound was soluble in benzene, toluene, xylene, alcohol and glacial acetic acid, fairly soluble in dilute alcohol, ether and carbon tetra-chloride.

An analysis of this compound showed the following result, when analyzed by the Carius method:

0.1000 gram of substance gave 0.1414 grams of AgBr and AgCl.

| Calculated for | Found |
|---|---|
| $C_{14}H_9O_4N_4Br_2Cl_3$ | 18.60 per cent Chlorine |
| 18.71 per cent Cl. 28.41 per cent Br. | 28.13 per cent Bromine |

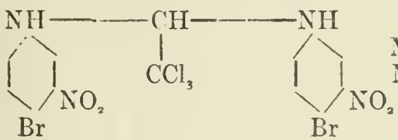
On treating the condensation product with concentrated hydrochloric acid and evaporating off the excess of acid, an insoluble yellow powder was obtained, which melted at 108°. When this yellow powder was treated with ammonia, the melting point remained at 108-9°, showing that the hydrochloride formed had been decomposed by the moist air, or that no hydrochloride had been formed and that the condensation product had been split into chloral and 4 brom 2-nitranilin, which melts at 108 9°. Water had no apparent effect upon the condensation product. On treat-

[1]Ber. der deutsch Chem. Ges. 6: 766.

[2]Jour. Elisha Mitchell Scientific Society, **30**, II, 63.

ing the condensation product with bromine, in a glacial acetic acid solution, a yellow crystalline compound settled out when the acetic acid solution was concentrated. This compound melted at 120-3° but rose in melting point to 130-1° when recrystallized from glacial acetic acid. This compound is very probably the 3, 4, 5-tri-brom aniline and a mixture of the lower bromine derivatives.

Tri-chlor-ethylidene-di-para-brom-meta-nitro-Phenamine



Molecular Weight, *563.35*.
Melting point, 147-9°.

For this preparation, five grams of the pure 4-brom-3-nitranilin which melted at 129-30°, were dissolved in 100cc. of benzol and to this were added 1.55 grams of chloral, after which the solution was heated over a water bath for two hours. This solution was allowed to cool and the by-product was filtered off. The filtrate was then evaporated down nearly to dryness or to a good sirupy consistency, and alcohol was then added, and the whole mass stirred well. Yellow needles came out in the cold solution, which were filtered off and dried. These crystals melted at 147-8° and on analysis by the Carius method gave the following result:

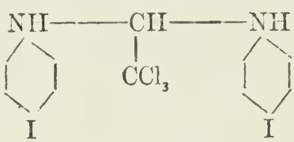
0.1000 gram of substance gave 0.0659 grams of AgBr. and 0.0746 grams of AgCl.

| Calculated for | Found |
|---|---|
| $C_{14}H_9O_4N_4Br_2Cl_3$ | 18.55 per cent Chlorine |
| 18.71 per cent Chlorine 28.41 per cent Br. | 28.04 per cent Br. |

When this condensation product was treated with concentrated hydrochloric acid and boiled, a light brown solution was obtained from which crystallized out long silvery white crystals, melting at 210-11° with a black decomposition. These crystals were not stable in the air or in a water solution, since they turned yellow and reformed the original 4-brom-3-nitraniline, similar to the reaction of the condensation product of the 4-brom-2-nitraniline. The free amine obtained by treating these crystals with water, melted at 129-30°, showing this compound to be the hydrochloride of 4-brom-3-nitraniline.

When bromine was added to this condensation product, dissolved in the least amount of cold glacial acetic acid, a light yellow or whitish yellow crystalline compound settled out, appearing as fan shaped crystals under the microscope and melting at 88°. On boiling the product with sodium hydroxide, a reddish brown oil was obtained, which solidified on cooling and melted at 97°. This melting point was raised to 98-101° by boiling with hot water, which gave an oil that crystallized out on standing. This bromine derivative was the tri-brom-nitro-aniline (2,4, 6-tri-brom-nitraniline), proved by its melting point and its non-combining power with acids.

Tri-chlor-ethylidene-di-para-iodo-Phenamine




Molecular Weight, *567.35.*

Melting point, 123°.

The para-iodo-aniline, used for this preparation, was made by the action of iodine chloride upon acetanilide. The acet group was eliminated by boiling with concentrated hydrochloric acid. This gave long, silvery-white needles, melting at 63°.

For this preparation, 1.5 grams of the pure para-iodo-aniline were used and to it was added 0.6 grams of freshly distilled chloral, after which 35cc. of benzol were added to the mixture and the whole solution was warmed up on a water bath for one hour. The by-product was then filtered off add the filtrate evaporated down to a sirupy consistency. Alcohol was then added to this sirupy mass and a steel gray mass of crystals were formed immediately. The crystal form of this compound was branching needles when seen under a microscope. This compound gave a melting point of 123°.

This iodo-condensation product was soluble in benzene, toluene, xylene, alcohol, acetone and glacial acetic acid, while it was not so soluble in dilute alcohol and gasolene.

An analysis of this compound by the Carius method gave the following results:

(1) 0.1000 gram of substance gave 0.1550 grams AgCl and AgI.

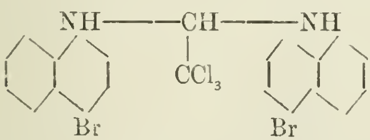
(2) 0.1000 gram of substance gave 0.0185 grams chlorine and 0.0471 grams of iodine.

| Calculated for | | Found | |
|---|---|---|---|
| $C_{14}H_{11}N_2Cl_3I_2$ | (1) | 48.72 per cent | I. |
| | | 18.30 ,, ,, | Cl. |
| 41.74 per cent I. and 18.70 per cent Cl. | (2) | 41.71 ,, ,, | I. |
| | | 18.49 ,, ,, | Cl. |

On treating this condensation product with concentrated hydrochloric acid, a hydrochloride is formed which decomposed at 206-10°, with the liberation of iodine, as proved by the purple vapor in the melting point tube. This hydrochloride yields, when treated with ammonia, para-iodo-aniline, melting at 63°. The hydrochloride of para-iodo-aniline also melted at 208-10°, with a purple colored vapor given off when it decomposed. These two reactions prove that the unknown hydrochloric acid derivative is the hydrochloride of para-iodo-aniline.

When this condensation product is treated with bromine, chloral is liberated and some para-iodo-aniline is regenerated as the hydrobromide, while still another part forms a brominated iodo-aniline. The iodo-aniline was identified by its melting point of 63°, when the hydrobromide was treated with ammonia, while the unchanged portion, from the treatment with ammonia, melted at 83-9°, which was possibly a brominated iodo-aniline.

Tri-chlor-ethylidene-di-4-brom-1-Napthylamine




Molecular Weight, *665.*

Melting point. 135-300°.

For this preparation, the 4-brom-1-napthylamine was prepared by treating acet napthylamine with bromine, forming the 4-brom-1-acet-napthylamine, and then removing the acet group by boiling for six hours with a saturated solution of caustic soda. This gave the 4-brom-1-napthylamine which melted at 102°.

2.5 grams of this 4-brom 1-napthylamine were treated with enough chloral to dissolve it and this mixture was heated over a steam bath for two hours, stirring constantly. This mixture was then treated with 100cc. of toluene and boiled for a few minutes, after which it was allowed to cool. The addition of toluene was accompanied by a decided change in color and bulk. Gasolene was next added to this part solution and part suspension, precipitating out the remainder of the product in light purple flakes. This compound never melted but sublimed at 135-50°, leaving behind a black charred mass, which decomposed at 300° with an effervescence. This condensation product was soluble in toluene, xylene, alcohol and glacial acetic acid, but it was very insoluble in gasolene.

Three analyses, by the Carius method gave the following results:

No. (1) 0.1000 gram of substance gave 0.1176 grams AgCl and AgBr.

No. (2) 0.1000 gram of substance gave 0.1182 grams AgCl and AgBr.

No. (3) 0.1000 gram of substance gave 0.1189 grams AgCl and AgBr.

When these precipitates were treated with chlorine and all the bromine in them displaced by chlorine the resulting weights were less by 0.0126, 0.0128, and 0.0129 grams than the original precipitates. Now taking the greatest loss in weight. 0.0129, and calculating the amount of bromine we have:

0.0129 x 1.797 (factor to convert the loss in weight into bromine) equals 0.0232 grams of bromine.

0.0232 divided by 0.4255 will give the amount of silver bromide which is 0.0545 grams of AgBr.

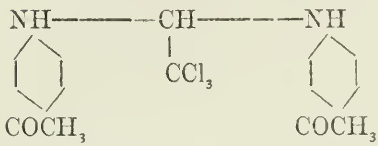
0.1189 (weight of the original precipitate) minus 0.0545 will give the amount of AgCl present in the original precipitate which is 0.0644 grams of AgCl.

0.0644 grams of AgCl equals to 0.0159 grams of chlorine.

| Calculated for $C_{29}H_{23}N_2Cl_3Br_2$ | Found |
|---|---|
| 15.99 per cent chlorine | 15.90 per cent chlorine. |
| **24.06 per cent bromine.** | **23.20 per cent bromine.** |

The reason that we have assumed that this compound has such a formula, that is with one molecule of toluene of crystallization, is because of the fact that three analyses from three samples made at three different times show such a constant value for the halogen content, and such a constant value for the loss is weight when the bromine is replaced by chlorine. These values do not indicate an addition product nor a condensation product without toluene of crystallization because the percentages of these two products are very much larger than that obtained from our product, as to the halogen content. We find however that when this compound is treated with hydrochloric acid, the original 4 Br-1-napthylamine is regenerated and chloral is liberated. The first of these compounds is detected by its melting point and by its behavior, while chloral is obtained by distilling a mixture of this condensation product and hydrochloric acid, after it has been made strongly alkaline with sodium hykroxide. Chloroform can be detected by a faint odor and by the iso-carbylamine odor, with aniline and sodium hydroxide, thus proving the presence of the chloral group. Now since this compound cannot be the simple condensation or the simple addition product, which are the only two simple chloral compounds, and since it does contain chloral it undoubtedly contains toluene of crystallization. When the reaction product of chloral and 4-brom-1-napthylamine is treated with toluene a perceptible change takes place and the compound becomes more bulky, so this led us to the belief that one or more molecules of toluene were held mechanically as toluene of crystallization. When these several values were calculated, for one, two and three molecules of toluene, it was found that one molecule approximated our result the closest. In order to prove this it was attempted to heat an air dried sample to constant weight at 150°, but this failed for the compound sublimed and gave a white crystalline compound exactly similar to the original 4-brom-1-napthylamine when it was heated. From this we saw that we had a dissociation of the condensation product into chloral and the original 4-brom-1-napthylamine, which would take place as low as 100°. It was possible to get a loss in weight which was equal to 7 83 per cent of the total weight at 80°, but here also the decomposition stopped the work for it began to decompose as low as 80° on prolonged heating. The theoretical for loss in weight for one molecule of toluene is 13.84 per cent.

Tri-chlor-ethylidene-di-para-Aminoacetophenone




Molecular Weight, *399.35.*

Melting point, 162°.

For this preparation 2.0 grams of the para-aminoacetophenone melting at 106-8°, were used and to it was added one gram of chloral. After this mixture had been triturated well in a beaker with a stirring rod, 50c. c. of toluene were added and the whole solution boiled which caused a flocculent whitish-yellow precipitate to settle out. This bye-product was filtered off and the filtrate concentrated to about half of its bulk over steam. On cooling large colorless crystals came out, showing thin rectangular plates under the microscope, when recrystallized out from dilute alcohol. Some of these rectangular plates showed a very uniform rounding off of the corners, presenting an elliptic form. This compound melted at 162° to a red liquid and gave on analysis, by the Carius method, the following result;—

0.0700 gram of substance gave 0.0747 grams AgCl.

| Calculated for, $C_{18}H_{17}O_2N_2Cl_3$, | Found |
| --- | --- |
| 26.63 per cent chlorine. | 26.36 per cent chlorine. |

This compound was soluble in toluene, benzene, xylene, and alcohol. It was also soluble in hot, dilute alcohol, but very insoluble when cooled down, so this gave a very good crystallizing medium for purification.

When this condensation product was treated with concentrated hydrochloric acid and warmed on a water bath, a yellowish-white, crystalline compound settled out, melting at 180-1°, giving a red colored decomposition. The action of hydrochloric acid upon the free aminoacetophenone gave a compound melting at the same place and giving the same red colored decomposition, showing the unknown hydrochloride to be the hydrochloride of para-aminoacetophenone.

The action of bromine upon this condensation product was somewhat complicated, for we were not able to get back all the original free amine as the hydrobromide. When a cold saturated solution was treated with one molecule of bromine and allowed to cool, a light, greenish-yellow crystal mass came out, melting at 180°, to a red liquid and giving a slight decomposition. This bromine derivative, on treating with strong ammonia, gave an oil and a red colored solid. The red colored solid was very probably an hydroxy derivative of the bromine compound, which decomposed with water, while the oil solidified and gave a melting point of 108-10° when it was allowed to cool and crystallize out. This latter was very probably the original aminoacetophenone, but the red colored liquid and the red colored oil could not have been, since the aminoacetophenone gave no red color when boiled with an alkali. The melting point of the red colored compound was not determined for it decomposed into an oil so fast that it was nearly impossible to get a pure sample with which to work.

The action of Chloral upon Tri-chlor Aniline.

Alexander Einner, in the Annallen,[1] says that it is impossible to condense with chloral an amine, in the benzene ring of which there are three or more negative groups. Having been able to condense some amines which had two unlike negative groups in the benzene ring, it was thought that by the use of a higher boiling point solvent it might be possible to get a condensation to take place and if not by the higher boiling point solvent, why the high pressure of the sealed tube might cause the tri-chlor aniline and chloral to condense. The results of this work were not satisfactory, since it was impossible to get the condensation reaction to take place between the tri-chlor aniline and chloral. The results of this work are given below:

(1). 1.0 gram of tri-chlor aniline was used and to it was added one gram of chloral. This mixture was dissolved in xylene

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[1]Annallen, **302**: 340-380.

and boiled for six hours. At the end of this time the tri-chlor aniline crystallized out as if no chloral had been present, melting at 77-8°. No change had taken place.

(2). 1 0 gram of the tri-chlor aniline was used and to it was added 1.0 gram of chloral. This mixture was dissolved in toluene and boiled for six hours At each two hour interval a small amount of substance was taken out and allowed to crystallize, by evaporating down over steam. No change had taken place for the three samples each melted at 77-8°, showing that it was the unchanged tri-chlor aniline.

(3). Tri-chlor aniline and an excess of chloral, without a solvent, were heated up in a sealed tube and temperature kept at 100° for four hours. Two samples were taken out, one at the expiration of two hours and the other at the expiration of four hours.

Neither sample showed a change, for each melted at 77-8° and showed the long, silvery-white needles of tri-chlor aniline.

13

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## A VISIT TO THE YOSEMITE AND THE BIG TREES.

BY W. C. COKER.

Coming up the hot valley of the San Joaquin from Los Angeles I arrived, July 5th, 1908, at Merced, a small town on the Southern Pacific, where change is made to the short line of railroad that, after a short run, strikes the Merced river and follows up its canyon to El Portal, the gateway to the Yosemite. This stretch of road, climbing hard all the way, passes entirely through the chaparral covered foot hills and ends, at about three thousand feet altitude, on almost the exact lower edge of the magnificent coniferous belt that clothes the western flanks of the Sierras. Leaving the expansive plains of the San Joaquin valley, where there is little arborescent growth except along the rivers, the train passes through a region of low, rolling hills, covered at this season with dead and parched grass, and decorated with fine "specimen" trees of the blue or Douglas oak (*Quercus Douglasii*), that gives this region its peculiar park-like aspect not paralleled in any part of the east. This Douglas oak, with its bluish foliage, contrasting finely with its light gray bark, its wide spreading, rounded tops and isolated habit of growth, is one of the most beautiful and decorative of American trees.* In addition to the

* The well known live oaks (*Q. agrifolia*) of the Pacific slope, which may be seen at their best at Berkley, have much the same habit, but their crowns are even more expanded and their lower limbs often flatten out their branches on the ground.

blue oak there is scattered through the lower and more fertile valleys the California weeping or post oak (*Q. lobata*), a fine, tall tree, often with pendant branches.

After a short while we leave behind the lower, grassy foothills and enter the second or chaparral belt, of higher and more precipitous hills, where we follow the rugged canyon of the Merced. Here the whole surface is covered with the characteristic shrub or chaparral growth of low, harsh and intricate bush that is often impenetrable except for the trails. Of the plants that make up this inhospitable expanse the most abundant are chemisal or greasewood (*Adenostoma fasciculatum*), which often occupies many acres to the exclusion of all else; *Ceanthus cuneatus*, one of the most impenetrable of all; several species of *Manzanita* (*Arctostaphylos pungens, viscida, tomentosa*); the two buckthorns, *Rhamnus crocea* with pretty red berries, and coffee berry (*Rhamnus Californica*), with black berries; Christmas berry (*Heteromeles arbutifolia*), also with fine red berries; the dwarfed ash (*Fraxinus dipetala*); and the curious yerba santa or mountain balm (*Eriodictyon Californicum*), which has the leaves covered with an extremely sticky varnish. In July the yellow flowers of the California buckeye (*Aesculus Californica*) make this shrub a conspicuous part of the chaparral, particularly in the higher parts.

The only trees that rise above the general level of this chaparral are *Quercus Douglasii*, which is even more common than farther down, *Q. Wislizeni*, one of the western live oaks which does not enter the higher mountains, and the black oak or Kellogg's oak (*Q. Californica*), a common oak of higher altitudes which chooses the more protected situations. All of these oaks may be very much stunted in places and thus scarcely break the monotony of the brush.

The only pines that can meet the murderous conditions of the hills are the digger pine (*Pinus Sabiniana*) and the knob-cone pine (*Pinus attenuata*). The first is common on all the hills up to three thousand feet elevation, but it is a small pine and is so scattered, and so sparse of foliage, that it has little effect on the general appearance of the country. Its cones are very large and heavy, and its seeds plump and edible. It is from the Digger Indians, who gather these seeds for food, that the tree takes its common name. The knob-cone pine is not nearly so common, and I did not see any of it from the train on my way up. It forms close, but very much scattered groves, and one often misses it in passing through the hills. This pine has the remarkable habit, in common with several other American pines, of retaining its cones unopened for many years. When fire kills the tree the cones open and all the seeds formed through the life of the tree are shed at once, thus planting a new grove at the time it is needed.[1] *Pinus attenuata*[2] is said to be more abundant north of the Merced than south of it.

The vegetation on the edges of the Merced river offers, of course, a striking contrast to that of the hills. Alders (*Alnus rhombifolia*) twenty or thirty feet high, large willows (*Salix fluviatilis* var. *argyraphylla*) very like our black willow, small willows (*Salix lasiandra*), ash (*Fraxinus biflora*), and good sized poplars (*Populus trichocarpa*) make up the larger growth. The most abundant shrubs are the button-ball (*Cephalanthus occidentalis*), the sweet-shrub (*Calycanthus occidentalis*),with fragrant brown flowers, *syringa* (*Philadelphus Lewesii*), most noticeable above El Portal, elder (*Sambucus glauca*), and the buckeye (*Aesculus Californica*), which grows also on the dry hills. Masses of the wild grape (*Vites Californica*) spread over the rocks and shrubs near the river.

Four or five miles below El Portal there appear along the river's edge a few small sentinels of yellow pine (*Pinus ponderosa*), sent down from the immense forest above, but giving little promise of what is to come. The California laurel (*Umbellularia Californica*) with strongly scented foliage also becomes notice-

[1] See John Muir's "Mountains of California," and my article on "Vitality of Pine Seeds and the Delayed Opening of Cones" in American Naturalist, 43: p. 677. Nov. 1909.

[2] *Pinus tuberculata* of some authors.

able about this time and extends on up to the Yosemite Valley. Of those great conifers that make so magnificent a display in higher altitudes the next to appear is the incense cedar (*Libocedrus decurrens*). It may be seen along the river just below El Portal.

Arriving at El Portal about dark, the night was spent there. An early start for Yosemite prevented much botanizing, but time was found to make out the more conspicuous growth of the place. The yellow pine (*Pinus ponderosa*) has here gotten out from the river bed and taken its place as one of the dominant trees of the hills. In fact, El Portal lies on the very edge of the coniferous-forest belt, and the red pine being the hardiest species of the belt is the only one represented here. The Digger pine still holds on at El Portal, but its upper limit is reached and it is lost almost immediately on starting for Yosemite.

Walking out from the hotel towards the east one passes small trees of blue oak (*Q. Douglasii*), golden cup oak (*Q. chrysolepis*), mostly low and scrubby, black oak (*Q. Californica*); and the shrubs, coffee berry (*Rhamnus Californica*), manzanita (*Arctostaphylos viscida*), with deep red, polished branches, California laurel (*Umbellularia Californica*), buckeye (*Aesculus Californica*) in flower in July, poison oak (*Rhus diversiloba*), dwarfed ash (*Fraxinus dipetala*), and a little *Rhamnus crocea,* a low shrub with red berries. A little way up the hill, behind the hotel, the peculiar sticky plant *Eriodictyon glutinosum* was found, and in a slight depression in the rocks two species of small willows were growing; one was *Salix lasiandra* and the other, *S. Bakeri,* a recently recognized species. Near these was found a small tree of the Oregon crab apple (*Malus rivularis*). The mountain mahogany (*Cercocarpus betulaefolius*) probably grows near here but was seen by me only once, on dry soil farther up the Merced.

Lower down the hill, in front of the hotel, the western redbud (*Cercis occidentalis*), an attractive small tree or shrub, and the elder (*Sambucus glauca*) were plentiful.

Along the river grew the plants that have already been described as occupying such a situation, and in wet places here was collected the large fern *Woodwardia spinulosa.* Among the bare rocks or flats by the river were the peculiar little ferns *Pellea andromedaefolia* and *Pellea ornithopus,* the latter looking more like a toy fir tree than a fern. Forming mats on the large rocks on the lower hillside was *Selaginella rupestris,* a relative of the ferns, that is found in similar situations in the Eastern States.

Along the rapidly ascending road that climbs through the Merced gorge for twelve miles to the Yosemite Valley there is noticed a constant change in the vegetation with the gradually increasing altitude. Immediately above El Portal there appears sparingly along the river that peculiar evergreen tree, the California nutmeg (*Tumion Californicum*), with fruit about the size and color of a green gage plum. Inside the fruit[3] is a nutmeg-like seed that gives the common name to the plant. The tree, as it appears here, is small, scraggy and irregular in habit, and only a few reached twenty-five feet in height and eighteen inches in diameter near the base.

The California yew (*Taxus brevifolia*), an evergreen related to *Tumion,* is said to grow along this road, but I missed seeing it. Many of the plants mentioned at El Portal do not reach the Yosemite. The Digger pine ends where Tumion begins, then, a mile or so farther, and the red bud disappears, then in succession the buckeye, the ash, the grape, the poison ivy,[3] and *Tumion* (about half way up). *Calycanthus* and *Philadelphus* extend to within a mile or two of the valley floor.

A wax-myrtle (*Myrica Hertwegi*) is reported as growing along the Merced below the Yosemite, but I did not find it.

The blue oak does not ascend for any distance above El Portal, but the black oak and golden cup oak extend up through almost the entire coniferous belt, and are much larger and finer in the Yosemite than lower down.

In the dry wood along the road the strong scented tar-

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3 Strictly speaking, as the plant is a Gymnosperm, the whole "fruit" is a seed.

4 A few pieces of poison ivy have been found as high up as the valley walls, but it is extremely rare there.

weed, or bear clover, (*Chamaebatia foliolosa*), with minutely dissected leaves and white, strawberry-like flowers, is plentiful. It is called "bear clover," says Mrs. Brandegee, "because it bears not the least resemblance to clover, and the bear will have nothing to do with it."

The incense cedar (*Libocedrus decurrens*), already mentioned as beginning down by the river near El Portal, and the red pine (*Pinus ponderosa*) increase in size as they advance up the gorge until they reach the magnificent proportions exhibited in the Yosemite.

Entering the Yosemite Valley I drove through almost its entire length and stopped at Camp Currie, which is stationed under Glacier Point near the upper end. The camp was situated in a fine grove of red pine and incense cedar, and in the immediate vicinity are good specimens of silver fir (*Abies concolor*). A few trees of the Douglas spruce (*Pseudotsuga Douglasii*) grow on the talus at the foot of the south wall, a few hundred yards from the camp. There is none of the great sugar pine (*P. Lambertiana*) around this camp, and although it occurs sparingly farther down, it does not reach its best proportions at any place in the valley.

Other coniferous trees that occur in the valley and on the heights are, according to Mrs. Brandegee,[5] *Abies nobilis,* "in some places, as near the foot of the Yosemite fall," *A. magnifica,* "along the whole line of the south side of the valley and in great abundance near Glacier Point," *Tsuga Pattoniana,* "found on benches and mountain sides at Cathedral Peak," *Pinus monticola,* "Sentinel Dome, Cloud's Rest, etc."

The black oak (*Q. Californica*) and golden cup oak (*Q. chrysolepis*) become large trees here, thirty or forty feet high, and make a conspicuous part of the woods around the camp. Nuttall's flowering dogwood (*Cornus Nuttallii*) is another attractive small tree that is common here. Two good clumps of it stand just in front of the Le Conte Memorial Building, a stone lodge erected

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[5] The Flora of Yo Semite. Zoe, **2**: 155. 1891.

in memory of Prof. Joseph Le Conte, the famous geologist and lover of these mountains, who died in the valley in July, 1901.

The shrubs of the dry and sandy valley floor around Camp Currie are *Ceanothus integerrimus,* a rather tall plant with feathery white flowers, *Ceanothus cordulatus,* a much lower and somewhat thorny spreading bush, coffee berry (*Rhamnus Californica*), manzanita (*Arctostaphylos viscida*), California rose (*Rosa Californica*), gooseberry (*Ribes Menziesii*), currant (*Ribes sanguineum*), wild cherry (*Prunus demissa*), and a little sage brush (*Artemizia tridentata*), the shrub that is so common in the dry deserts.

July is not the best time for flower display in the valley, as the long summer dry spell is then at its worst, but a number of attractive flowers still survive even in dry soil. Conspicuous among these is *Godetia quadrivulvera* with its variable flowers of purplish hues. The curious little low herb with pink and white clusters of flowers called pussy paws (*Spragua umbellata*) is common on the western side of Camp Currie and further down the valley.

Other attractive flowers are milkweed (*Asclepias speciosa*), yarrow (*Achillea millefolium*), the fragrant mint (*Monardella lanceolata*), the tall *Lopanthus urticifolius,* with purplish-pink flowers in spikes, *Penstemon heterophyllus,* the conspicuous lupine (*Lupinus parviflorus*), and our old eastern friend *Brunella vulgaris.*

Other less noticeable herbs of the dry flats are *Erigeron foliosus, Apocynum cannabinum, Lessingia leptoclada, Epilobium paniculatum, Eriogonum nudum, Lotus Nevadensis* and *Lotus crassifolius.* The Bracken fern (*Pteris aquilina*) is common. In slightly damper places grow *Geranium dissectum,* heartleaf (*Asarum Hartwegi*), wild strawberry (*Fragaria Californica*), columbine (*Aquilegia truncata*), and a small willow (*Salix lasiolepis*).

Along the trail which leads for about one mile up the valley to the Happy Isles grow nearly all the plants above mentioned, and where the soil is low and damp, as it is in several places near this trail, good sized trees of alder (*Alnus rhombifolia*), and poplar (*Populus trichocarpa*) appear. With these grow the flowering raspberry or salmon berry (*Rubus parviflorus*), very like our eastern one, raspberry (*Rubus leucoderme*), the small dogwood with inconspicuous flowers (*Cornus occidentalis*) resembling our *C. Amomum*, and some of that most beautiful of all Yosemite shrubs, the western azalea (*Azalea occidentalis*).

Before reaching Happy Isles the trail passes, near the pumping station, through a wet marsh, where the alders and poplars grow into good sized trees. Both the large and small dogwoods appear on the edges of this marsh, and both raspberries also. Very conspicuous by the plank walk in the marsh were the cow parsnip (*Heracleum lanatum*), a rank growing, umbelliferous plant, a beautiful, tall lily with numerous small flowers (*Lilium parvum*), large lady ferns (*Asplenium felix-foemina*), two species of horsetail (*Equisetum robustum* and *Equisetum telmateia*), and the orchid *Habenaria leucostachys*. In a dry spot across the river, not far below the pumping station, was a colony of the mountain snow berry (*Symphoricarpus mollis*).

Between Camp Currie and the river are some damp, open meadows covered with fresh grass and flowers. Here were collected *Helenium Biglovii*, *Oenothera biennis* var. *grandiflora*, *Geranium incisum*, and *Brodiaea lactea*. Crossing the river here I found the june berry (*Amelanchier alnifolia*) as a low shrub on the river's edge, and in a sandy spot were a few trees of the lodge pole pine (*Pinus Murrayana*) that I have not seen mentioned as occurring on the floor of the valley.

Following the trail from this place to Mirror Lake I found growing on its banks *Salix lasiandra* and *Salix lasiolepis*. *Cornus occidentalis* grew in a damp place near, and in a wet open marsh a little way south of Mirror Lake, the following were collected: *Veronica scutettata*, *Stellaria longipes*, *Hypericum anegalloides*, *Helenium Biglovii*, *Dodecatheon Hendersoni*, *Mimulus Langsdorffii*, *Trifolium involucratum*, *Galium trifidum*, *Viola blanda*, *Ranunculus alismaefolius*, and, in a damp pasture near, *Lotus Torreyi*.

In the deep, rich wood, near the foot of Yosemite falls, were a good number of pine drops (*Plerospora Andromedea*), a large saprofhytic plant, one to three feet high, of a reddish brown color.

It is related to our indian pipe, and to the brilliant red snow plant (*Sarcodes sanguinea*) that occurs abundantly a little higher up.

The trail to Nevada Falls as it winds above Vernal Falls passes many attractive sun and rock loving species that are not found in the level valley. All are protected by some means against the excessive heat and drought to which they are exposed, as by dense hairs, succulent leaves, etc. A pretty little yellow composite covered with white wool (*Eriophyllum confertiflorum*) was in full bloom, as were also the succulent *Sedum obtusatum*, with yellow flowers, *Penstemon breviflorus*, with yellowish flowers striped with pink, and *Penstemon Newberryi*, with red flowers. *Gilia Hookeri*, with pretty pink and white flowers, formed low, dense mats, like our *Phlox subulata*. *Patentilla glandulosa*, with yellow, and *Scrophularia Californica*, with purplish flowers, grew singly in the crevices. Here also grew alum root (*Heuchera micrantha*) with tall white panicles of minute white flowers of a delicate, mist-like beauty.

The low spirea-like shrub (*Holodiscus discolor*), with leaves densely hairy beneath and white flowers in corymbs, and a low honeysuckle (*Lonicera interrupta*) were common.

The ferns that were able to survive the heat and dust of the rocky slopes were *Aspidium rigidum* var. *argutum*, *Pellea densa*, *Pellea Bridgesii*, *Pellea brachyptera*, *Cystopteris fragilis*, and *Cheilanthes gracillima*. The last has the leaves thickly clothed beneath with a dense felt of salmon colored hairs.

A species of mistletoe (*Phoradendron villosum*), not very different from our eastern one, was growing abundantly on *Quercus chrysolepis* along the trail.

Near the foot of Nevada Falls the trail passes a low place full of springs and several extensive pools of shallow water. In a damp spot here I found for the first time the silk-tassel tree (*Garrya Fremontii*), a rather tall shrub with opposite leaves and black juice. Other plants found here, and not seen before, were *Veronica serphyllifolia*, *Veronica Americana* and a species of *Podosciadium*.

Near the top of Nevada Falls grew *Cotyledon Nevadensis*, with yellow flowers and thick leaves, another species of alum root

(*Heuchera rubescens*), and the pretty red tipped paint brush (*Castilleia parviflora*).

On the rocks at the top of Nevada Falls I saw my first cedar (*Juniperus occidentalis*), a weather-worn old tree of great age. This tree is always low but sometimes gets a large trunk diameter, as much as ten feet according to Mrs. Brandegee (Flora of Yo Semite: Zoe, vol. 2, page 160).

The golden cup oak is also abundant here, as it is at all points at this elevation. It is hard at first to be convinced that the various forms of leaves that this plant exhibits, some with edges as smooth as our live oak, others as toothed and prickly as holly, can all belong to the same species. The acorns are equally variable.

Behind Camp Currie a steep and difficult trail leads up the almost perpendicular cliff for three thousand three hundred feet to Glacier Point above. The climb up this trail was a delightful experience. On the way are passed, in dry places, yellow pine (*Pinus ponderosa*), silver fir (*Abies concolor*), Douglas spruce (*Pseudotsuga Douglasii*), golden cup oak (*Quercus chrysolepis*), *Holodiscus discolor,* coffee berry (*Rhamnus Californica*), *Cotyledon Nevadensis* and most of the ferns that were seen on the rocks above Vernal Falls.

Along the course of a little brook up which the trail climbed for a good way near the top were growing *Azalea occidentalis,* in full bloom, the little bush maple (*Acer glabrum*), California laurel (*Umbellularia Californica*), small dogwood (*Cornus occidentalis*), flowering raspberry (*Rubus parviflorus*), and the flowers *Aquilegia truncata, Saxifraga peltata* and *Smilacina amplexicaulis.* Here also, to my surprise, were growing our own maiden hair ferns of the East (*Adiantum pedatum*).

At Glacier Point *Pinus Jeffreyi* occurs. It looks very like *P. ponderosa* and by some is considered only a variety of it. Under the pines here are extensive masses of the low bush chinquepin (*Castanopsis sempervirens*). Near the top of Sentinel Dome which rises up another thousand feet above Glacier Point I found a single tree of lodge pole pine (*Pinus Murrayana*), but did not find any *P. Monticola,* which is said to grow near the summit.

From Glacier Point the coach road winds over plateaus and ridges at an elevation varying from five to seven thousand feet, and passes the whole distance through as magnificent a forest as the earth can show. Yellow pine (*P. ponderosa*), Jeffrey's pine (*P. Jeffreyi*), white fir (*Abies concolor*), Douglas spruce (*Pseudotsuga Douglasii*), and incense cedar (*Libocedrus decurrens*) —all trees that we had already met with—here reach the largest proportions; but that grandest of all pines, the sugar pine (*P. Lambertiana*), seen before in the valley, but scarce there, is the most imposing spectacle of the forest. It often reaches a diameter of ten or twelve feet and a height of over two hundred feet. The small lodge pole pine is nowhere a conspicuous component of the forest, but a few well developed trees occurred along the road. They were shedding their pollen on July 7th.

On the floor of the forest through most of the distance were large expanses of the odd little bear clover or tar weed (*Chamaebatia foliosa*), already mentioned. The whole plant gives off a very penetrating aromatic odor (it can hardly be called a fragrance) that can be detected almost anywhere in the woods.

Open wet meadows were beautifully adorned with shooting stars (*Dodecatheon Jeffreyi*) and azaleas (*A. occidentalis*).

Arriving at Wawona late in the afternoon, I spent the night there and made an early start by the foot trail for the Mariposa Grove of Big Trees, about seven miles away.

Along this trail grew black oak, sugar pine, yellow pine, incense cedar, a great deal of *Chamaebatia, Ceanothus integerrimus, Ceanothus cordulatus* and the beautiful blue-flowered *Ceanothus parvifolius;* a little manzanita (*Arctostaphylos viscida*) and gooseberry (*Ribes Menziesii*), some currants (*Ribes sanguineum*), hazel nuts (*Corylus Californica*), roses (*Rosea Californica*), flowering raspberry (*Rubus parviflorus*), and in damp places *Cornus occidentalis.* Flowers in bloom were mariposa lilies (*Calicortas venustus* and its variety *purpurascens*), paint brush (*Castilleia parviflora*), iris (*Iris Hertwegi*), *Aquilegia truncata, Brunella vulgaris, Montia perfoliata, Lupinus polyphyllus,* and another large lupine that I have not yet been able to determine. In a meadow near Wawona were *Godetia biloba, Mimulus Langsdorffii* and *Brodiaea grandiflora.*

About four hours were spent in the upper and lower groves of the Mariposa reservation of Big Trees (*Sequoia gigantea*). The two groves, containing together about five hundred of the sequoias, lie close together in a depression at an elevation of about five thousand five hundred feet.

Other coniferous trees associated with the sequoias are white spruce (*Abies concolor*), Douglas spruce, yellow pine, sugar pine and incense cedar. Very abundant on the ground was the low white-flowered snow bush (*Ceanothus cordulatus*) and the spreading blue or lilac-flowered *Ceanothus parvifolius,* one of the most beautiful shrubs I ever saw. *Chamaebatia* was common in dryer places, and roses (*R. Californica*), dogwood (*Cornus occidentalis*), azaleas (*A. occidentalis*), flowering raspberries (*Rubus parviflorus*), hazel nuts (*Corylus Californicus*), and braken fern were plentiful. *Lilium parvum, Cypripedium montanum,* iris, and the conspicuous and curious blood-red snow plant (*Sarcodes sanquinium*) added their bright colors to the forest floor.

The Mariposa grove of big trees is only one of a number of scattered groves of these giants that occur "along the west slope of the Sierra Nevada Mountains, from the middle fork of the American River to the head of Deer Creek, a distance of 260 miles."[6] In massiveness the largest trees of the Mariposa grove are equal to any, but as the tallest tree here is only 272 feet high there are a number of trees in other groves that surpass them in this respect, one for example in the Calaveras being 325 feet in height.

"The Grizzly Giant" is the most impressive and probably the oldest tree in the Mariposa grove. It is thirty feet in diameter at the base, and twenty feet at ten feet from the ground. Its top has been shortened and sadly battered by storm and lightning, and its base deeply burnt by many fires, but the impression that it gives of massive grandeur and venerable age has not been lessened

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[6] A Short Account of the Big Trees of California: Bulletin No. 28: U. S. Dept. of Agric. Division of Forestry.

by its many vicissitudes. The age of this patriarch has been variously estimated, but it is probable that it is not less than 4,000 or more than 5,000 years old.

From the exposed surface of a burn that had eaten deep into the body of one old tree I cut away the charred wood for a space at a distance of about a foot from the surface until I could count the annual rings. There were twenty-five of them to the inch. If this rate should be continued to the center of a tree twenty-five feet in diameter it would establish its age as 3,750 years, and it is not likely that many of the trees are older than this. However, we cannot accurately estimate their ages by such a method, as it is certain from the counting of rings in felled or burnt trees that the rate of growth varies greatly in different situations and at different ages. The greatest age that has been definitely established for any of the Big Trees is something over 4,000 years, a figure that was determined by John Muir by counting the rings in one of the largest trees in the King's River forest.

The impressiveness of the great sequoias surpassed even my exalted expectations. As with all great objects and scenes, the mind cannot conceive for a time the full report of the senses. Indeed, the imagination can never fully grasp the fact that this towering mass before us was in its prime in those forgotten days when the psalmist asked, "What is man, that thou art mindful of him? and the son of man, that thou visitest him?" Gradually the impression deepens until there falls upon us a sense of awe that cannot be produced by any of the temples or monuments that are built of hands.

" I am a part of all that I have met," says Ulysses, and, surrounded by the majesty of these cavernous groves, one can not but believe that had they stood guard over the history of man they would have added a finer fibre to his heart, and to his spirit a more noble aspiration.

Chapel Hill, N. C.

# THE PRODUCTION OF MORBID CHANGES IN THE BLOOD VESSELS OF THE RABBIT BY ALCOHOL *

BY WILLIAM DE B. MAC NIDER, M.D.

## Introduction.

The production of morbid changes in the lower animals by the use of drugs, various chemicals and, in some cases, by the employment of mechanical devices, has opened an instructive field for medical investigation. The general aim of such investigation has been, first, to determine whether definite and fairly constant pathologic changes could be produced by the use of various agents, and, second, after this has been determined, to arrest or to modify these changes by the use of other agents of a remedial nature.

In recent years there has been developed an extensive literature through the work of various investigators on experimental arteriosclerosis. The contributions of Josie, Kurt, Fischer, Klotz, Miller[1] and others have demonstrated that degenerative arterial changes follow the intravenous injection of adrenalin, digitalin and diphtheria toxin. Boinet and Romany and Klotz, using the *Bacillus typhosus* and streptococcus, have with the same animals produced arterial changes primarily affecting the intima, which is greatly thickened by endothelial proliferation.

Klotz,[2] in an interesting series of experiments, in which rabbits

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* From the Laboratory of Experimental Therapeutics of the University of Chicago, S. A. Matthews, M.D., Director. A preliminary report; reprinted from The Archives of Internal Medicine, March, 1909.

[1] Miller (J. L.): Spontaneous Arterial Degeneration in Rabbits. Jour. Am. Med. Assn., 1907, xlix, 1789.

[2] Klotz: Centralbl. f. allg. Path. u. Physiol., 1908, xix, 535.

were suspended by their hind legs, demonstrated a rise in arterial pressure by the mechanical aid of an excessive amount of blood in the aorta and forelegs. Five animals thus treated developed changes in the aorta, carotid, subclavian and brachial arteries. No changes were demonstrated in the control animals. It has also been shown by Klotz[3] that bacterial toxins are capable of producing changes in the intima of the aorta and pulmonary artery.

Undoubtedly spontaneous arterial disease occurs in the lower animals, and perhaps more frequently in the rabbit, for this animal is peculiarly susceptible to surroundings and changes which depart from the normal. The occurrence of spontaneous aortic disease in rabbits has been demonstrated by Wells and also by Amy B. Miles.[4] The probability that such changes are not very frequently encountered is, however, strengthened by the report of Pearce,[5] who examined sixty-two rabbits. Of these, fifty were normal rabbits. Vascular lesions were found in but three, and in each case consisted of a few minute patches of sclerosis at the beginning of the aorta. In the remaining eleven animals degenerative changes were found in the aortas of four. These were animals that had been subjected to the action of typhoid and other sera.

The object of the present investigation was to determine whether sclerotic changes could be produced in the vascular system of a rabbit by the use of alcohol.

## METHOD OF ADMINISTRATION, DOSAGE AND THE IMMEDIATE EFFECT OF ALCOHOL

At the commencement of this series of experiments the alcohol in 30 per cent. solution was given intravenously. By such a method of administration, changes, if any should develop in the

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[3] Klotz: Brit. Med. Jour., 1906, ii, 1767.

[4] Miles (Amy B.): Spontaneous Aortic Diseases in Rabbits. Jour. Am. Med. Assn., Oct. 5, 1907, xlix, 1173.

[5] Pearce (R. M.): Occurrence of Spontaneous Arterial Degeneration in the Rabbit. Jour. Am. Med. Assn., 1908, li, 1056.

vessels, could be logically ascribed to the direct action of the alcohol, and thus there would be eliminated the many modifications to which the drug is subjected before it reaches the vessels when it is introduced into the stomach. The intravenous injections were, however, rapidly followed by the formation of thrombi in the neighboring vessels, necessitating the drug being given by the stomach. For this purpose a small, soft rubber catheter was used.

In each case for the first few days 25 c.c. of a 10 per cent. solution was given once a day. After this the quantity was increased to 50 c.c. and the strength of the solution to 20 per cent.

The immediate effect of the alcohol was greatly enhanced by this method of administration, the excitement being marked. In all the animals the respirations and heart were markedly accelerated. This condition usually lasted about an hour. Then the animal would become drowsy. At this stage voluntary movements were slow and all muscular acts imperfectly coordinated, Following an hour or more of drowsiness the animals would usually fall asleep for two to six hours. Their return to the normal was gradual, the effect of the alcohol lasting on an average of twelve hours.

## GROSS AND MICROSCOPIC CHANGES PRODUCED IN THE VESSELS OF ANIMALS SUBJECTED TO THE ACTION OF ALCOHOL

In the following observations the aorta was the vessel selected for study in determining the presence or absence of sclerosis. The agents used were Zenker's fluid, hematoxylin and eosin:

*Experiment 1.*—The subject received 50 c.c. of 20 per cent. alcohol for thirty-four days. The aorta at its origin and for a distance of 1 cm. was visibly thickened. Just at its commencement and situated so as to encroach on one of the coronary openings there was a nodule the size of a pin-head. The microscopic examination of the tissue taken from the thickened portion of the arch showed very clearly, when compared with sections of the thoracic portion of the aorta, a thickening of both the inner and middle coats of the vessel. This change in the internal coat was due to a proliferation of the connective-tissue cells in the subendothelial layers. In the media small round cells and fibroblasts were numerous between the muscle bundles. The muscular element was not degenerative. There had been no transition of the connective-tissue cells into true fibrous tissue. The change was an early one and apparently as extensive in one coat as in the other. The nodule referred to was situated in the intima and was formed principally of elongated cells, which stained poorly and had undergone a granular, non-fatty degeneration. There were no adjacent changes in the media.

*Experiment 2.*—The subject received 50 c.c. of 20 per cent. alcohol for forty days. The aorta showed no evidence of atheromatous changes. Sections through the vessel at various levels showed no evidence of disease.

*Experiment 3.*—The subject received 50 c.c. of 20 per cent. alcohol for forty days. The thoracic aorta was the seat of a clearly defined atheromatous ulcer. Elsewhere the vessel was normal. The ulcer in the thoracic involved both the intima and media. Its floor was formed by the adventitia, and consisted of young connective tissue in the cellular and fibrous stages. Calcification was not present.

*Experiment 4.*—The subject received 50 c.c. of 20 per cent. alcohol for thirty days. The aorta was normal in structure.

*Experiment 5.*—The subject received 50 c.c. of 20 per cent. alcohol for twenty days. The animal was accidentally killed. The aorta presented no evidence of disease.

*Experiment 6.*—The subject received 50 c.c. of 20 per cent. alcohol for forty-two days. The aortic valves were thickened, and felt rough. The aorta showed two calcareous patches, one in the arch and one in the thoracic portion. There was a diffuse thickening of the inner and middle coats, the histologic appearance bearing a close resemblance to the changes seen in the aorta of the first animal. The areas of calcification occupied chiefly the intima, but extended also to the media, having ruptured the inner elastic lamina. Here it may be interesting to note that the hyperplastic changes which have been demonstrated in the inner coats of the aorta were not preceded by localized degeneration and weakening of the middle coat. The changes in the vessel were usually of a diffuse character. There was evidently no pronounced localization in the action of the substance or substances which induced changes in the vascular system from the continuous use of alcohol.

*Experiment 7.*—The subject received 50 c.c. of 20 per cent. alcohol for fifty days. The aorta showed an atheromatous ulcer 1 cm. from the aortic ring and a small warty growth on one of the aortic valves. The ulcer involved the intima and a portion of the media. The amount of cell infiltration in the media was less than in preceding cases.

*Experiment 8.*—The subject received 50 c.c. of 20 per cent. alcohol for forty-four days. There were no changes in the intima. Sections through the aorta at various levels frequently showed in the middle coat, between the muscle bundles, collections of small round cells. Other than this there was no evidence of connective-tissue overgrowth.

*Experiment 9.*—The subject received 50 c.c. of 20 per cent. alcohol for thirty-three days. The upper portion of the aorta showed several areas that were visibly and palpably thicker than the surrounding vessel. Sections through these areas showed the thickening to be due to a proliferation of the subendothelial connective tissue. The cells and nuclei stained well. There was no evidence from the staining reaction or from the size of the cells or their nuclei that the degenerative changes existed.

*Experiment 10.*—The subject received 50 c.c. of 20 per cent. alcohol for twenty-four days. The aorta was normal.

*Experiment 11.*—The subject received 50 c.c. of 20 per cent. alcohol for fifty days. The aorta showed a patch of thickening behind one of the semilunar valves and in the thoracic aorta there were several deep ulcers. Opposite the larger of the ulcers the vessel was bulged (early aneurism formation). This area measured 1 cm. in its longest diameter. The floors of the smaller ulcers, which were not so deep as the larger one, were found in the middle coat. The floors did not consist of the histologic elements of the media, but of young connective tissue fibres and spindle-shaped cells. This reparative fibrosis lessened as sections away from the ulcer were examined. It did not come to a clear-cut termination, but the marked localized connective tissue overgrowth existed to a less degree in a general thickening of the middle coat at some distance from the ulcers.

*Experiment 12.*—The subject received 50 c.c. of 20 per cent. alcohol for fifty-four days. The aorta was the seat of several areas of nodular sclerosis, the nodules being to a great extent confined to the intima, while the media presented the usual diffuse connective-tissue hyperplasia.

*Experiment 13.*—The subject received 50 c.c. of 20 per cent. alcohol for fifty-four days. There was diffuse cell infiltration of the middle coat.

A STUDY OF THE AORTAS OF PRESUMABLY NORMAL ANIMALS

The animals used as controls were all full grown; eight of the number were old. The aortas of the sixteen control animals were examined in the same way as the vessels of those animals subjected to the action of alcohol.

The following is a summary of the changes found:

In thirteen of the animals the aorta was free from both general and localized thickening. In the three remaining animals the vascular changes were as follows: In one aorta there was a sclerotic nodule in the arch; in the two remaining vessels atheromatous ulcers were found in the thoracic aorta. There was an absence of diffuse thickening, especially in the media. This observation naturally suggests that the etiologic factor in the development of the vascular changes in the control animals was of a localized nature. The frequency with which diffuse changes are seen in the vessels of the alcoholic animals suggests some diffusely acting agent.

## PRELIMINARY DEDUCTIONS

The number of animals used in these experiments is too small to permit the formulation of any permanent conclusions from the results. Definite sclerotic changes developed in the aorta in a decided majority of the animals that were subjected to the action of alcohol. Such was the case in nine of the thirteen animals used. These changes varied in intensity from a small round-cell infiltration of the media to the production of an atheromatous ulcer 1 cm. in its longest diameter. The most constant change was a diffuse thickening of the media. Similar changes were present in the vessels of relatively few normal animals. The changes which were present were localized and were not nearly so extensive as those seen in the vessels of the alcohol animals, even though the control animals were old, the other animals not being full grown.

A continued study of this subject will consist in the following measures: First, an attempt will be made to demonstrate morbid changes in the vessels of a larger series of animals. Second, if it can be definitely proved that such changes are produced fairly constantly by the use of alcohol, an endeavor will be made to determine whether the alcohol *per se* is capable of causing such results, or whether the changes arise indirectly by the action of alcohol inhibiting the activity of the various digestive enzymes and predisposing to or directly leading to some type of autointoxication.

CHAPEL HILL, N. C.

# ALCOHOL *

BY WM. DE B. MAC NIDER, M.D.

(a) The Pharmacological Action of Alcohol.

(b) Logical Indications for the Use of Alcohol as a Therapeutic Agent.

(c) Changes Produced Experimentally in the Blood Vessels of Rabbits Subjected to the Action of Alcohol.

The subject under discussion may be approached and studied with benefit from many points of view. At the present time a consideration of alcohol from a sociological viewpoint would be of interest, but for many reasons, this side of the subject will be severely left alone.

Like many other questions of medical interest, the older they are, the more they are subjected to discussion and criticism, the more interesting they become; especially in these latter years when they can be approached, studied, and in some cases solved by scientific methods of investigation. Such a statement is certainly true concerning this old yet often discarded drug — alcohol.

Occurring as it does, free in nature, or at least, the elements which enter into its formation are free, namely, ferments and starches, it was natural enough for the ancients to use the drug as a remedial agent and a beverage. Judging from the older writings, the influence of alcohol upon the nervous system and the circulatory system, both in a dilute and a concentrated form, was well understood. The modern conception of the action of alcohol upon the body both before and after absorption, and in dilute and concentrated solutions, differs in some essentials and in many

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* Reprinted from The Charlotte Medical Journal, Aug., 1909.

details from the views regarding its action which were held some years ago. This change has been largely due to the study of the drug from an experimental laboratory side. Approached in such a way, many of the confusing factors can be eliminated which exist in a very pronounced and exaggerated form at the bed-side, which may mask and overshadow the action of a drug and render deductions which are seemingly logical fallacious. We frequently hear the remark that conclusions arrived at when the individual is eliminated from the equation must be of slight practical value. In this statement there is a pronounced element of truth which can with ease be discerned when we think of the influence the mind exerts over the various functions of the body in health and in disease. This influence cannot be considered as it should be and cannot be appreciated in most laboratory work. The mental status of an individual usually plays but a feeble part in determining the action of a drug and on this account the pharmacological action of the vast majority of drugs can be scientifically determined and logical deductions for their use arrived at by laboratory experiments upon anesthetised animals.

## THE PHARMACOLOGICAL ACTION OF ALCOHOL

The action of alcohol when used externally depends upon the concentration of the solution employed. The stronger solutions, 80-95 per cent., are not so strongly germicidal as the weaker, 30-40 per cent., solutions. When the stronger solutions come in contact with the bacterial cell they produce a superficial coagulation of the albuminous material of the cell body which prevents the penetration of the drug and lessens its germicidal power. In addition to this direct germicidal action, alcohol indirectly acts as a germicide by dissolving fatty material in and around the hair follicles and allowing a deeper and more perfect action of other germicides, such as the bichloride of mercury.

The influence of alcohol on digestion, and the role it plays as a food are two questions which have been severely battered by laboratory investigations and clinical observations.

When the drug is used in a concentrated form it undoubtedly increases the amount of blood to the gastro-intestinal tube. This increased vascularity persists, and as a result of its persistence leads to an over-production of mucous and a connective-tissue hyperplasia in the mucous and sub-mucous coats of the stomach and intestines. The mucous which results from an increased blood supply to the mucous glands is readily decomposed by the intestinal bacteria with the formation of acids or fermentation. Just what part these acids play in chronic alcoholic auto-intoxication, and to what extent they inaugurate the diffuse connective-tissue overgrowth in the body, which is most marked in the liver, blood vessels, and kidneys, is an intensely live question, with which we hope to do something experimentally.

When alcohol is used in small amounts and in a well diluted form, before or during meals, it acts to a less degree as an irritant, but simply this action increases the amount of blood to the stomach and intestinal glands. As a result of the glands receiving more blood, their activity is increased and there is an increased output of digestive juices.

When alcohol is given undiluted, with the idea in view of aiding digestion, it undoubtedly does harm, as the stronger solutions check the action of unorganized ferments.

Alcohol is readily absorbed from the intestines and is usually quickly oxidized into its final endproducts, $CO^2$ and $H^2O$.

The influence which this drug has after its absorption is the part of the alcohol question which has been most severely discussed by the laboratory student and clinician. As a result of the rapid combustion of the drug after its absorption it furnishes heat and energy to the body, lessens the combustion of fats and carbohydrates, and in this way indirectly acts as a food. This point seems fairly well established and is generally accepted. The point concerning the action of alcohol which is still the subject of a lively discussion is whether or not it can be considered a circulatory stimulant. If alcohol be given to a healthy individual in a fairly strong solution it is the common observation that the heart quickens its action, there is an increased output of blood into the arterial system and the pulse tension is raised. A similar effect upon the circulatory system can be produced by other gastric irritants, such as ammonia, ether, and capsicum. This stimulating action of the drug is very likely a gastric reflex. To determine this point we have on several occasions anesthetised a rabbit with chloral hydrate solution and connected the animal's carotid artery to a mercury manometer, so as to accurately record the arterial pressure. At intervals of fifteen minutes a small soft rubber catheter was introduced into the animal's stomach and 30 c.c. of a 30 per cent. solution of ethyl alcohol administered. The heart's rate and the animal's blood pressure were recorded every five minutes. There was no appreciable rise in blood pressure and but a very slight acceleration of the heart. These experiments certainly support the the belief that the acceleration of the heart after the use of alcohol is a gastric reflex from irritation and that when the reflexes have been abolished as a result of the anesthesia the quickening of the heart and the subsequent rise in pressure from alcohol does not occur.

I am firmly of the belief that there are certain infectious diseases in which alcohol is of the greatest value as a circulatory support. I do not say stimulant, for with the ordinary interpretation of this term it would convey a false meaning. In pneumonia, typhoid fever and, more rarely, tuberculosis, we frequently see patients with a fast heart, a soft, small pulse, rapid respirations, and muttering or maniacal delirium. In short, these are outward manifestations of an over-stimulated central nervous system. The stimulus is the toxin, and it at first gives rise to this picture of stimulation, and unless it is stopped leads to over-stimulation, fatigue, and a state of inactivity of the central nervous system which is manifested by a state of coma which frequently precedes death.

In such cases following the use of alcohol, especially in pneumonia, it is a common observation to note that the delirium lessens, sleep is induced, the heart's action becoming slower and stronger. The cells of the arterial nervous system are so depressed that they no longer respond to the stimulus of the toxin, the state of fatigue is prevented and the integrity of the cell is maintained. It has been clearly demonstrated, experimentally, by Dolly that as a result of over-stimulation structural changes of a degenerative nature develop in the cells of the central nervous system, and furthermore that these changes frequently lead to an actual rupture and death of the cells.

### EXPERIMENTAL ARTERIO-SCLEROSIS BY THE USE OF ALCOHOL

As a result of the use of the higher animals for teaching and experimental purposes, there has developed in this country an enormous amount of literature along the line of experimental pathology. Such work is not only essential to the proper teaching of several of the rudimentary branches in the medical curriculum, but it is the only way which many problems in pathology and pathological physiology can be approached and solved.

The blood vessels of the lower animals were early used as a field for such experimental work. Among the investigators who have attempted to produce atheromatous changes in the vessels are Josie, Fischer, Kurt, Klotz and Miller. Various drugs and other agents have been employed, but the most satisfactory results have been obtained by Miller, who used solutions of adrenalin and physostigmine.

It is a well known fact that the majority of individuals who use alcohol continuously, develop some type of arterio-sclerosis. The severity of the process varies from a slight induration of the aortic valves and a few atheromatous patches in the aortic arch to a diffuse arterial sclerosis which exists in the peripheral vessels as the classical "pipe stem" arteries.

It was the object of our investigations to determine, first, if such changes could be produced experimentally by alcohol in the vessels of the lower animals. Secondly, to determine, if possible, if these changes were due, *per se,* to the alcohol, or if other secondary factors entered into their production; and thirdly, to attempt to find some remedial agent which would have either a direct or indirect influence upon the morbid process.

The rabbit was the animal chosen for this work, as they are comparatively cheap and easy to handle. The alcohol was given by the stomach through a soft rubber catheter. For the first few days 25 c.c. of a 10 per cent. solution was given, and after this the amount was increased to 50 c.c. and the strength of the solution to 20 per cent. A few of the animals died from accidental causes. In those that lived the alcohol was continued for nearly eight weeks. At the end of this time the rabbits were killed by chloroform, complete post-mortems were held, and the heart, aorta and iliac vessels were removed for microscopic study.

There were fourteen animals in this first series which were subjected to the action of alcohol as described above. Of the fourteen animals the vessels of ten showed distinct evidence of some type of arterial degeneration. These changes varied greatly as to the severity and location. In four of the animals the vascular changes were evidently early and consisted chiefly in a diffuse connective-tissue overgrowth in the cellular stage, which affected principally the middle coat of the vessels, but which was beginning to be more pronounced around the blood vessels of the middle coat, *e. g.,* the vasa vasorum. This localization of young connective tissue around these nutrient vessels of the middle coat is important. For when the connective tissue reaches its fibrillary stage and contracts it will inevitably compress the lumen of the vessel which it surrounds and prevent an adequate amount of nutrition in the form of blood from reaching the media. This will aid, if not directly cause, degenerative changes of the middle coat.

In the vessels of three of the animals the most marked changes were to be found in the inner coat. This consisted in a subendothelial hyperplasia, which existed in patches, and which was most marked in the aortic arch. A few of the patches were losing their nuclei, failing to stain and beginning to develop into atheromatous ulcers.

The aorta of the three remaining animals showed decided evidence of late degenerative changes. These changes existed as well defined punched out or scooped out atheromatous ulcers. Their location, with one exception, was in the arch of the aorta. The inner and middle coats of the vessel were always involved, the floor of the ulcer usually being formed by the outer part of the middle coat. In the aorta of one of the animals the ulceration was very extensive. The ulcers were large, had a scooped out appearance, and were found in the abdominal as well as the upper aorta. The floor of one of these ulcers was formed by the outer coat of the vessel, which was bulged out on the surface as a sacculated aneurism. A detailed account of this work has been published in The Archives of Internal Medicine. We feel certain that degenerative changes can be produced in the vessels of the rabbit by the use of alcohol. On account of the small number of animals used the report is preliminary in its character.

The question naturally arises, might not these changes which were found in the vessels have developed spontaneously and not be ascribable to the alcohol action.

To eliminate this possible source of error the vessels of eighteen presumably normal rabbits were removed and studied microscopically. In fifteen of the vessels there was no evidence of general or localized sclerosis. In the remaining three vessels there was in one a small round cell infiltration of the media. In the other two there were a few patches of thickening of the internal coat, which were in the early stages of the formation of atheromatous ulcers.

The second point of this work was to determine, if possible, the cause of the vascular degeneration. The following observations, we hope, will have some weight and throw some light on this side of the question. Those animals which did not develop arterial changes, and those in which these changes were only slight, gained in weight under the use of alcohol, had good appetites, and showed no sign during life or at the post-mortem of gastro-intestinal irritation; while those animals which developed the most pronounced vascular changes, and those in which these changes were fairly severe, lost in weight under the use of alcohol, had a poor appetite, and a diarrhoea during most of the time the alcohol was being used. At the post-mortem such animals showed an acute diffuse enteritis of moderate severity.

All of the animals were receiving the same amount and the same strength of alcohol. Some developed gastro-enteritis and in these arterial changes were most pronounced. Others did not develop a gastro-enteritis and in these animals there was either no arterio-sclerosis or the arterial changes were slight. Evidently some factor other than the alcohol *per se* has an influence in the production of degenerations of the blood vessels. Just what this is we are at present in no position to say. The apparent fact certainly affords an interesting field for speculation and investigation. It is not unlikely that in some individuals as well as in some animals alcohol causes an acute catarrhal state of the stomach and intestines. As a result of this increased amount of blood to the mucous glands of the stomach and intestine they become hyperactive and produce an excessive amount of mucous which is discharged into the intestine and here decomposes with the liberation of organic acids and other bodies which are absorbed and lead primarily to a chronic auto-intoxication, and secondarily to vascular degeneration.

### CONCLUSIONS

1. When used externally in weak solutions alcohol is directly and indirectly a germicide.

2. When used in weak solutions, in the stomach and intestine, it acts mildly as an irritant, increases the amount of blood to these structures, and increases the functional activity of the gastric and intestinal glands.

3. In strong solutions, by acting as a gastric irritant it reflexly increases the rate and perhaps the force of the heart beat.

4. After absorption it has no direct effect upon the circulatory system but through its sedative action on the central nervous system it prevents the heart from being over stimulated and in this way is of distinct value in some of the acute infectious diseases.

5. Arterial degeneration may be produced in the lower animals by alcohol.

6. The degenerative vascular changes are likely not entirely due, primarily to the alcohol acting as such, but to the absorption of products from the intestine which the alcohol has indirectly caused to be formed.

CHAPEL HILL, N. C.

# DRAINAGE OF NORTH CAROLINA SWAMP LANDS *

BY JOSEPH HYDE PRATT.

For several years the North Carolina Geological and Economic Survey has been making preliminary examinations of the swamp lands of the State in order to determine:

1. The character of swamp; whether the soil is suitable for agricultural purposes, or whether it is too peaty in character.

2. Whether the peat swamps contain a sufficient quantity of peat and of such quality that it would be marketable.

3. Whether the swamps can profitably be drained for agricultural purposes.

There are approximately 4,505 square miles of swamp lands in eastern North Carolina, besides thousands of acres of "overflow" land, a great deal of which is susceptible of reclamation, if properly drained.

The approximate amount of swamp land in twenty-eight of the eastern counties in North Carolina is as follows:

| County | Sq. mi. | County | Sq. mi. |
|---|---|---|---|
| Beaufort | 177 | Columbus | 300 |
| Bladen | 192 | Cumberland | 30 |
| Camden | 162 | Dare | 344 |
| Chowan | 80 | Gates | 45 |
| Craven | 238 | Jones | 139 |
| Currituck | 40 | New Hanover | 25 |
| Duplin | 125 | Pamlico | 325 |
| Hyde | 387 | Pender | 370 |
| Martin | 86 | Perquimans | 92 |
| Onslow | 134 | Robeson | 130 |
| Pasquotank | 80 | Tyrrell | 251 |
| Bertie | 57 | Pitt | 40 |
| Brunswick | 300 | Sampson | 118 |
| Carteret | 126 | Washington | 262 |
| | | Total | 4,505 |

Or 2,883,200 acres.

* Reprinted from Journal of the American Peat Society, Vol. 2, No. 3. Oct., 1909.

Several areas in Bladen, Carteret, Craven, Duplin, Onslow, Pasquotank, Pender and Wilson Counties have been examined, and in nearly all cases no engineering difficulty stands in the way of draining these lands. In the early history of the state there were three obstacles in the way of the practical drainage of these swamp lands:

1. The cost of clearing the land, inasmuch as the timber had little or no commercial value at that time.

2. The excessive cost and almost impossibility of digging adequate canals and ditches to take care of the water.

3. The lack of adequate laws that would permit the carrying out of a drainage proposition.

Fortunately, all these obstacles are now removed; the value of the timber on nearly any swamp area is worth more than the cost of clearing the areas for agricultural purposes; the great advance made in the manufacture of dredges now makes it possible to dig canals of any size at comparatively low cost; and the General Assembly of 1909 has passed an act which makes it possible to carry out almost any drainage proposition.

It may be of interest to the readers of the Journal of the American Peat Society to know something regarding this act. The title of the act is as follows:

"An act to promote the public health, convenience and welfare by leveeing, ditching and draining the wet, swamp and overflowed lands of the State, and providing for the establishment of levee or drainage districts for the purpose of enlarging or changing any natural water courses and for digging ditches or canals for securing better drainage or providing better outlets for drainage, for building levees or embankments and installing tide gates or pumping plants for the reclamation of overflowed lands, and prescribing a method of so doing; and providing for the assessment and collecting of the cost and expense of the same, and issuing and selling bonds therefor; and for the care and maintenance of such improvements when constructed."

Under the provisions of this act it is now possible for a majority of the resident land owners in any proposed drainage district, or the owners of three-fifths of all the land which would be included in the proposed district, to petition the clerk of the superior court of the county in which the greater portion of the swamp area is located that he declare such land a Drainage District. The petitioners file a bond with the clerk equal to $50.00 for each mile of canal that it is estimated would have to be constructed to carry out the drainage proposition, such money to be used in paying the cost of the preliminary examination that the clerk of the court has ordered made; provided, such examination shows that the drainage of the land is not a feasible proposition. For making this preliminary examination, the clerk appoints a competent civil and drainage engineer and two resident freeholders of the county, who shall determine:

1. Whether the proposed drainage is practicable or not.
2. Whether it will benefit the public health or any public highway, or be conducive to the general welfare of the community.
3. Whether the improvement proposed will benefit the land sought to be benefited.
4. Whether or not all lands that are benefited are included in the proposed Drainage District.

On the filing of this preliminary report, if favorable, the clerk appoints a certain day when the report shall be further heard and considered, at which time any one interested in the drainage proposed may appear before the court and give reasons why his lands should not be included in the Drainage District, and why he thinks the proposition is not feasible, or why he thinks the cost will be greater than the benefit. If the court does not sustain him in his objections, he has the right to appeal to the superior court of the county in term time; provided he accompanies his appeal with a bond acceptable to the clerk of the court. After the objections to this preliminary survey have all been settled, the clerk shall order that a complete survey and report shall be made of the district, that plans and specifications shall be drawn up showing the locations of the canals and ditches, methods of construction and estimated cost. The viewers shall determine the ratio of benefit that each acre will receive by drainage, and, in making the assessment against each acre this ratio shall be used. In classifying the lands to determine the ratio of benefits, consideration is given to the degree of wetness of the land, its proximity to the ditch or a natural outlet, and the fertility of the soil.

The land thus benefited shall be separated into five classes: The land receiving the highest benefit shall be marked "Class A;" that receiving the next highest benefit, "Class B;" that receiving the next highest benefit, "Class C;" that receiving the next highest benefit, "Class D;" and that receiving the smallest benefit, "Class E." The holdings of any one land owner need not necessarily be all in one class, but the number of acres in each class shall be ascertained, though their boundary need not be marked on the ground or shown on the map. The total number of acres owned by one person in each class and the total number of acres benefited shall be determined. The total number of acres of each class in the entire district shall be obtained and presented in tabulated form. The scale of assessment upon the several classes of land returned by the engineer and viewers shall be in the ratio of 1, 2, 3, 4 and 5—that is to say, as often as 5 mills per acre is assessed against the land in Class A, 4 mills per acre shall be assessed against the land in Class B, 3 mills per acre in Class C, 2 mills per acre in Class D, and 1 mill per acre in Class E. This shall form the basis of the assessment of benefits to the lands for drainage purposes.

When this final report is handed in to the clerk of the court, he shall notify all the land owners that upon a certain date there will be a hearing of the said report at which any land owner may appear in person, or by counsel, and file his objections in writing to the report of the viewers. It shall be the duty of the court to carefully review the report and the objections filed thereto. If, in the opinion of the court, the cost of construction, together with the amount of damage assessed, is not greater than the benefits that will accrue to the land affected, and if the assessments are just and equitable, the court shall confirm the report of the viewers and declare the Drainage District established. If, however, the court does not confirm the report, the proceedings shall be dismissed at the cost of the petitioners. During the hearing of this court, any land owner has the privilege of appealing from the decision of the court to the superior court in term time, and the establishment of the Drainage District is delayed until such appeal is settled.

As soon as the Drainage District is declared established, the court shall appoint three disinterested persons, who are known as the "Board of Drainage Commissioners," and they are immediately created a body corporate under the name and style of "The Board of Drainage Commissioners of ——— District." This board of commissioners has the power to issue bonds of sufficient amount to cover the cost of drainage, the land being collateral for the bonds, none of which can be sold below par. The bonds are thirteen-year bonds, payable in ten installments, the first installment to be due at the end of three years from the issuing of the bonds, the same to bear 6% interest. The money necessary to pay the interest and bond issue is raised by assessment on the land, according to the benefits derived, as mentioned above. This assessment constitutes the first and paramount lien, second only to state and county taxes, upon the land assessed, and is to be collected in the same manner and by the same officer as state and county taxes.

Provisions are also made in the act for crossing land with a ditch, for crossing highways and railroads, for notifying the railroads of such crossings, and for assessments of damages upon them and upon individuals. Provision is also made for the control and repair of the canals and ditches after they have been once constructed. In order to protect the ditches, canals, levees, etc., that have been constructed in carrying out the plans for the Drainage Districts, the act makes it a misdemeanor for any person to injure or damage or obstruct in any way these ditches and canals.

As a result of the passage of this act, six drainage districts are already in the course of formation: one in Currituck County, known as the Moyock Drainage District; one in Hyde County, which contemplates the drainage of Lake Mattamuskeet and about 70,000 acres adjoining it, making a total of about 120,000 acres in the drainage district; another in Beaufort County, north of Belhaven, containing approximately 25,000 acres; 4,000 acres in Pender and Duplin Counties, known as Angola Bay Swamp, containing possibly 47,000 acres; 5,000 acres in Pender and Bladen Counties, which contemplates the reclamation of a large and fertile area in Lion Swamp, and 6,000 acres near Wilson, Wilson County.

Work has already been commenced in the Moyock District, the Wilson, and one in Beaufort County. Plans and specifications have been drawn up for the drainage of Lake Mattamuskeet, Angola Bay and the Lion Swamp areas. An application has also been received for the establishment of a Drainage District in Chowan County.

The above will show the interest that has already begun to be taken in the drainage of North Carolina swamp lands. It has been known for a long time that many thousands of acres of these swamp lands contain the most fertile soil to be found in the state, and now that the General Assembly has made drainage possible, there is plenty of capital ready to undertake the drainage of these fertile swamp lands, realizing that they will be able to dispose of the lands at a good profit after they have been thoroughly drained.

The drainage of the vast swamp areas of eastern North Carolina means not only additional wealth to the state, in the form of reclaimed agricultural lands, but it will mean improved roads through large areas that are now practically impassable and inaccessible. It will also mean better school facilities for the children and it will greatly improve the healthfulness of this section of the state.

CHAPEL HILL, N. C.

# THE MINERAL PRODUCTION IN NORTH CAROLINA DURING 1908 *

BY JOSEPH HYDE PRATT

The financial stringency and general business depression that swept over this country the latter part of 1907 and the greater portion of 1908 had a decided effect upon the mineral production of North Carolina during 1908. This was felt especially in the building stone and clay product industries, which are largely dependent upon building trades for their market. As these form by far the larger portion of the mineral production of the state, there was, consequently, a considerable falling off in the total value. Its effect, however, was also noticed in the production of practically all of the minerals of the state, there being but one or two that showed any increase in production for 1908 over that of 1907.

The total value of the mineral production for 1908 was $2, 307,116, as compared with $3,173,722, value of the 1907 production, a decrease of $766,606. This mineral production can be readily divided into four divisions:

1. The production of the metals, gold, silver, copper and iron;

2. The production of non-metallic minerals, as talc, barytes, etc.;

3. Structural materials, as building stone, brick, etc.; and

4. Pottery clays.

There is given in the table below the value of the 1908 production divided up according to these divisions:

* Reprinted with slight changes from Press Bulletin No. 33, North Carolina Geological and Economic Survey, No. 26, 1909.

| | |
|---|---|
| Metals | $ 177,600 |
| Non-metallic minerals | 258,902 |
| Structural materials | 1,771,603 |
| Pottery and pottery clays | 99,011 |
| Total value | $2,307,116 |

In the production of the precious metals, North Carolina easily maintains first place in the Eastern States, although its total production is small. The gold production of 1908 was 4,716.32 fine ounces, valued at $97,945, an increase of 740.24 fine ounces, and of $15,302 in value over the production of 1907. The county producing the largest amount of this production was Montgomery, with Rowan second. The output of silver and copper, which are very closely related to each other, was very greatly below the production of 1907, the copper being valued at only $2,560, as compared with $116,410, the value of the 1907 production. All of the principal copper mines were idle during 1908.

In the non-metallic minerals there was a slight increase in the production of millstones, but a decided decrease in the production of all the others.

The value of the structural materials produced during 1908, of $1,771,603, was a decrease of $389,415, as compared with $2,161,018, the value of the production of 1907. The greatest decrease was in the production of granite and common brick. In 1907 the value of the granite production was $906,476, while in 1908 it dropped to $802,927, a decrease of $103,549. The production of common brick in 1907 was 174,750,000, valued at $1,150,185, while the production of 1908 has fallen off to 144,192,000 brick, valued at $900,611. There were slight gains in the production of sand-stone, marble, and lime.

The value of the production of pottery and pottery clays in 1908 was $99,011, an increase of $3,284, as compared with $95,727, the value of the 1907 production. There is given in the table, on page 167, the mineral production in North Carolina for the years 1903-1908, inclusive. With the exception of gold, the production of all the minerals was affected by the financial condition of the country, and in many cases the increase or decrease in the production of a mineral is entirely due to increased prosperity or financial depression of the country. With some of the minerals, however, the decrease is due to other causes, such as excessive cost of production or working out of deposits.

Comparing the production of the various minerals during 1908 with those of the five previous years it will be seen that up to 1908 there has been a gradual increase in the production of those minerals which make up the larger proportion of the mineral production of the State, such as clay products, stone, monazite, mica and copper. The total value of the mineral products for 1908 is the lowest recorded since 1904, and up to this year there had been a steady increase in the total value of the products since 1900, when these statistics were first collected, with the exception of the year 1902.

During the past year many new mining properties have been opened up and developed and many inquiries have been received relating to the occurrence of different minerals of the State, which would indicate that the mineral production for 1909 would be considerably in excess of that of the previous year (see table on opposite page).

THE MINERAL PRODUCTION IN NORTH CAROLINA FOR THE YEARS 1903-1908.

| Mineral. | Value. | | | | | |
|---|---|---|---|---|---|---|
| | 1903. | 1904. | 1905. | 1906. | 1907. | 1908. |
| Gold | $ 113,604 | $ 123,924 | $ 129,153 | $ 122,008 | $ 82,195 | $ 97,495 |
| Silver | 16,907 | 19,132 | 20,216 | 30,944 | 14,299 | 668 |
| Copper | 67,037 | 36,600 | 88,000 | 135,829 | 116,416 | 2,560 |
| Iron | 78,540 | 79,846 | 70,352 | 75,638 | 113,488 | 76,877 |
| Garnet and Corundum | 12,250 | 6,586 | 9,000 | ........ | 13,500 | ........ |
| Millstones | 902 | 6,500 | 2,652 | 4,110 | 1,969 | 4,052 |
| Mica. Sheet | 86,300 | 100,724 | 100,900 | 205,756 | 209,956 | 114,540 |
| Mica. Scrap | 2,400 | 3,410 | 3,375 | 11,940 | 15,250 | 13,330 |
| Quartz | 36,827 | 36,269 | 13,659 | 12,578 | 1,664 | ........ |
| Precious stones | 1,525 | 10,600 | 3,350 | 5,000 | 7,580 | 570 |
| Rare minerals | 270 | 160 | ........ | ........ | 9,300 | ........ |
| Monazite | 58,694 | 79,438 | 107,324 | 125,510 | 54,824 | 37,224 |
| Zircon | 570 | 200 | 1,600 | 248 | 46 | ........ |
| Barytes | 21,347 | 33,930 | 21,670 | 10,020 | 18,855 | 10,580 |
| Talc and pyrophyllite | 76,984 | 65,483 | 74,940 | 66,979 | 74,347 | 51,443 |
| Mineral water | 13,085 | 21,902 | 38,755 | 31,413 | 40,302 | 27,163 |
| Graphite | 248 | 525 | 475 | 475 | ........ | ........ |
| Coal | 25,300 | 8,820 | 2,336 | ........ | ........ | ........ |
| Stone | 360,322 | 312,576 | 597,922 | 854,301 | 956,919 | 824,927 |
| Sand and gravel | ........ | ........ | 547 | 9,191 | 2,191 | 2,070 |
| Sand-lime brick | ........ | 17,500 | 29,103 | 32,975 | 38,808 | 14,000 |
| Kaolin and other clays | 76,000 | 76,670 | 85,622 | 90,036 | 85,505 | 85,649 |
| Clay products | 866,458 | 944,880 | 1,038,430 | 1,182,660 | 1,316,308 | 943,968 |
| Total value | $1,915,570 | $1,985,675 | $2,439,381 | $3,007,601 | $3,173,722 | $2,307,116 |

A general discussion of the mining industry in North Carolina during the year 1908 will be given in Economic Paper No. 18 of the Publication of the N. C. Geological and Economic Survey, Chapel Hill, N. C.

CHAPEL HILL, N. C.

# ADDITIONS TO THE FLORA OF THE CAROLINAS *

BY W. C. COKER

Collections made at intervals at Chapel Hill, Orange County, North Carolina, and in Darlington County, South Carolina, have resulted in the addition of the following species to the known flora of these states:

ACER FLORIDANUM (Chapman) Pax.

This tree is not uncommon on the sandy banks and alluvial bottoms of Morgan's Creek, near Chapel Hill, North Carolina. I have found it at several places here; and there are a number of medium-sized trees on the streets in the town of Chapel Hill that have been brought in from the surrounding country. In the creek bottoms the tree grows to a large size, forty feet or more high and two or more feet in diameter. The species has not been reported before from North Carolina, and the only South Carolina collection seems to be from "near Charleston" by J. H. Mellichamp, 1896 (herb. N. Y. Bot. Garden). It is possible that this collection was made from a tree brought in from a distance and planted by Michaux, but supposing it to be native at Charleston, the discovery of this species at Chapel Hill extends its known range about 230 miles northward.

*Acer floridanum* seems to approach nearest to *Acer leucoderme* Small, but according to Dr. Small the two are quite distinct, not only in characters of foliage and fruit, but also in habit. I have not seen *A. leucoderme* in the field, but it is said to be a shrub or small tree, preferring rocky banks in the piedmont or middle dis-

*Reprinted from the Bulletin of the Torrey Botanical Club, **36:** 635-638. 1909.

tricts, while *A. floridanum* is a large tree of alluvial bottoms, and confined principally to the coastal regions. That *A. leucoderme* also is present in Orange County seems certain, as it has been collected in the adjoining county of Durham to the east (herb. N. Y. Bot. Garden, from Biltmore Herb.).

HABENARIA NUTTALLII Small.

Collected in wet soil on the south side of Paper Mill Lake, Hartsville, South Carolina, August, 1908. This orchid has not been collected before in the state of South Carolina, and only at Wilmington in North Carolina (herb. N. Y. Bot. Garden, *W. M. Canby*, 1867). Towards the south it has not been found nearer than Florida and southern Georgia.

SOLIDAGO VERNA M. A. Curtis.

Collected on earth dam opposite Paper Mill, Hartsville, South Carolina, May, 1909. Hitherto this very rare plant has not been found except in eastern North Carolina and no exact locality is known except near Wilmington, where it was discovered by Rev. M. A. Curtis.

In the Flora of North America, Torrey and Gray (2: 205. 1842), *S. verna* is given on authority of Curtis from "open sandy pine woods near Wilmington, and Lenoir County, North Carolina," to which is added "(Florida, *Herb. Rafinesque!*)." But in Gray's Synoptical Flora of North America, Lenoir County, North Carolina, and Florida are omitted from its habitat and it is given only from "open and sandy pine woods near Wilmington, N. Carolina, *Curtis*." From this it would seem that its occurrence in Florida has not been established; but as to Lenoir County, which lies some seventy miles north of Wilmington, if Curtis said he found it there, its occurrence there can scarcely be doubted. In his "Catalogue of the Indigenous and Naturalized Plants" of North Carolina (Geol. and Nat. History Survey of North Carolina, Part III, Raleigh, 1867) Dr. Curtis himself gives *S. verna* only from the low districts "(low dist.)."

So far as I have been able to discover, *S. verna* has been distributed only by Rev. M. A. Curtis, Dr. T. F. Wood, and Mr.

Gerald McCarthy, all of whom seem to have collected their plants around Wilmington. The species is listed in Wood and McCarthy's Wilmington Flora (Journal of the Elisha Mitchell Scientific Society, 3: 77. 1886), and in McCarthy's distribution list of "Flora of Eastern North Carolina" of 1885.

The occurrence of the plant at Hartsville, South Carolina, extends its range about one hundred and ten miles to the westward.

JUNCUS ABORTIVUS Chapman.

Four plants were collected in a damp grassy meadow in Burnt Bay about one-third of a mile behind the residence of Maj. J. L. Coker, Hartsville, South Carolina. Comparison with a sheet from Chapman's own herbarium leaves no doubt that this determination is correct. The species has heretofore been known only from western Florida near the coast. The Hartsville station extends its range over four hundred miles northward.

SCRIPUS SUBTERMINIALIS Torr.

A large quantity of this rush, hitherto supposed to be entirely northern, was found in the stream just below the "race" at Kilgore's Mill, about one mile from Hartsville. The species ranges across the northern part of the United States and Canada and has not been reported before south of New Jersey. However, on examining the sheets of this species at the New York Botanical Garden, it was found that it had been collected at Morrisonville, Mississippi, by S. M. Tracy in 1898. It is therefore probable that the species will be found to extend over the Southeastern and Gulf states.

CYPERUS MARTINDALEI Britton.

This small sedge is very common in the sand hills near Hartsville, South Carolina. It has not been known before except from Florida and the Gulf Coast.

CROTALARIA PURSHII DC.

Reported in Small's Flora from "Georgia and Florida to Louisiana," and it does not seem to have been reported farther to the northeast. It was collected by me at Hartsville, South Carolina, in flat sandy pine-barrens and it has been collected by House in Oconee County, South Carolina, in 1906, and by Huger in North Carolina (herb. N. Y. Bot. Garden).

VACCININIUM FUSCATUM Ait.

Given in Small's Flora from "Georgia to Florida, Arkansas and Louisiana," and supposed to be a Florida and Gulf Coast plant. The species was collected in wet soil in "Burnt Bay," Hartsville, South Carolina, May 24, 1909. This extends its range three hundred miles northward.

GENTIANA ELLIOTTII Chapman [*Dasytephana parvifolia* (Chapm.) Small].

In the fall of 1907 a pure white form of this species was collected on the side of a ditch near the Pee Dee river at Society Hill, Darlington County, South Carolina, and sent me by Mr. P. H. Rogers.[1] The plant was again collected by Mr. Rogers at the same place in October, 1908. The plants are said to have been rather numerous in 1907, but the ditch was worked over soon after and in 1908 there were only a few to be found. I now have four specimens of this interesting form. Albinos seem not to have been previously recorded for this species.

LIMODORUM TUBEROSUM L. (*Calopogon pulchellus* R. Br.).

Three plants of the white form were found among sphagnum on the edge of a bay on the north side of Paper Mill Lake, Hartsville, South Carolina, May 23, 1909, and Mr. P. H. Rogers has since collected it in the vicinity of Hartsville. This albino has been reported from Moor's Landing, New Jersey, by Dr. Britton (Bull. Torrey Club 17: 125. 1890) and by Paine from Genesee County, New York (Cat. Pl. Oneida County, 86. 1865), but I can find no record of its occurrence in the Carolinas. The normal form is plentiful at Hartsville.

In conclusion I wish to thank Dr. John K. Small and Dr. N. L. Britton for assistance extended me in the preparation of this paper.

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[1] It is interesting to note that Society Hill was for several years the home of the gifted botanist, Rev. M. A. Curtis.

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# TABLE OF CONTENTS

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# THE CONSERVATION AND UTILIZATION OF OUR NATURAL RESOURCES*

BY JOSEPH HYDE PRATT, STATE GEOLOGIST OF NORTH CAROLINA

## Introduction

The two parts of this subject may at first glance seem to be contradictions of each other, but as we stop to analyze the subject and consider it in its broadest sense, we will find that the conservation of our natural resources will mean not only their perpetuation but also that we will be enabled to utilize them perpetually. This can be accomplished by the aid of certain restraining laws which will work little or no hardship on any person or community and the final result will be of the greatest benefit to the State.

This question of the conservation of our natural resources has not sprung up suddenly but has been receiving the serious consideration of our greatest statesmen, scientists and manufacturers. The first direct result of this agitation was the calling together by the President of the United States of a Conference of the Governors of the States and Territories, which met at the White House, May 13, 14 and 15, 1908. The main object of this Conference was stated by the President in his letter of invitation to the Governors:

"It seems to me the time has come for the country to take account of its natural resources and to inquire how long they are likely to last. We are prosperous now; we should not forget that

*The illustrations used in this article have been loaned by the N. C. Geological and Economic Survey and have been used in its various publications.

it will be just as important to our descendants to be prosperous in their time."

That the members of this Conference were interested in this great question is shown by the declaration which was unanimously adopted by them as embodying their conclusions on this question of conservation. Let me quote briefly from this declaration, which will show the attitude of the Governors of the States and Territories of the United States:

"We, the Governors of the States and Territories of the United States of America, in conference assembled, do hereby declare the conviction that the great prosperity of our country rests upon the abundant resources of the land chosen by our forefathers for their homes and where they laid the foundation of this great nation.

"We look upon these resources as a heritage to be made use of in establishing and promoting the comfort, prosperity and happines of the American people *but not to be wasted, deteriorated or needlessly destroyed*.

"We agree that our country's future is involved in this, that the great natural resources supply the material basis upon which our civilization must continue to depend, and upon which the perpetuity of the nation itself rests.

"We declare our firm conviction that this conservation of our natural resources is a subject of transcendent importance, which should engage unremittingly *the attention of the nation, the States and the people* in earnest cooperation.

"We declare the conviction that in the use of the natural resources our independent States are interdependent and bound together by ties of mutual benefit, responsibility and duties."

This declaration was adopted unanimously by this conference of governors, scientists, jurists and statesmen representing perhaps the greatest body of men that has ever been gathered together in the history of this country. They urged upon the nation and the states to begin at once the conservation of their natural resources. They urged cooperation between the nation and the states and the closing words of the declaration, "and so conserve the foundations of our prosperity" can only be carried out in their entirety by the most liberal cooperation between the states and the nation; and between the states themselves.

The problems relating to the conservation of our natural resources are not local questions but national and state questions. They are questions that are of interest not only to the individual but also to the whole people. Thus, in adopting measures looking toward the conservation of these natural resources, the nation must be considered before the state and the whole people before the individual. Applying this same principle to the state, in any laws that are passed regulating conservation, the whole State must be considered before any county.

As every state is interested in the development of all other states forming the nation, so every part of a state is interested in the development of every other section, for no advancement can be made in one section or county without its being directly or indirectly of benefit to all other sections.

We are all part of the State of North Carolina and we will have to bear our share of whatever praise or disgrace may be meted out to her as a whole or to any part of her. The State's interests extend to the limits of her territory and as North Carolinians, we are interested in her deriving all the benefit possible from the development of her resources whether they be the forests, the swamp lands, and the fish and oysters of eastern North Carolina; the waterpowers, the forests, and minerals of the Piedmont section; or the hardwood forests, minerals, and water powers of the mountain section.

To obtain the most benefit, North Carolina must conserve and at the same time utilize these great natural resources with which she has been so abundantly supplied. To conserve them, they must, as has been stated before, be considered from the standpoint of the State and not from that of the county.

Let us see first what North Carolina's natural resources are. Given in the order of what I consider their importance they are:

1. Soils and products of the soil, as forests, etc.
2. Water Powers.
3. Mineral products, including coals, etc.
4. Products of the sea.

The development of the State is absolutely dependent upon these natural resources. Some of them are of much more importance than the others and some could perhaps be entirely destroyed (such as fish and oysters) without permanently checking the industrial advancement of the State; but its best advancement is dependent upon the conservation of them all.

When we stop to consider that the population of this country is now increasing about one-fifth of its total number each ten years, we begin to realize how many millions more of people must be fed and clothed from the products of our soil. By the middle of the present century, it is estimated that there will be about 150,000,000 in the United States. This increase is not confined to any one section of the country but there is a decided and steady increase in the population of all the States and Territories. In North Carolina there are now approximately 2,250,000 people but by the middle of this century this population will have increased to approximately 4,600,000. This large growth in population means a constantly increasing drain upon all our natural resources and it is, therefore, time that we as a State and as part of the greatest nation of the world, realize that our responsibility does not rest with providing for the present generation but that we must do our part towards providing for future generations by conserving and perpetuating for their use the great natural resources which we are now ourselves enjoying.

The American people have been called the most extravagant people in the world and, considered from the standpoint of the nation, we are the most extravagant inasmuch as we are extremely wasteful in the production and utilization of our natural resources; and take little thought toward creating a use for what are known as "waste products." It is perhaps not stating it too strongly to say that the wealth of the nation could be nearly doubled if careful consideration were given to the utilization of these waste products and the prevention of waste of the products that are utilized. This includes crops raised by our farmers, soils, forest products, minerals, and fish and oysters.

While this question of conservation is a national one, I wish to consider it principally in its relation to North Carolina and shall take up a discussion of the conservation of the natural resources already referred to and what their conservation will mean to this State.

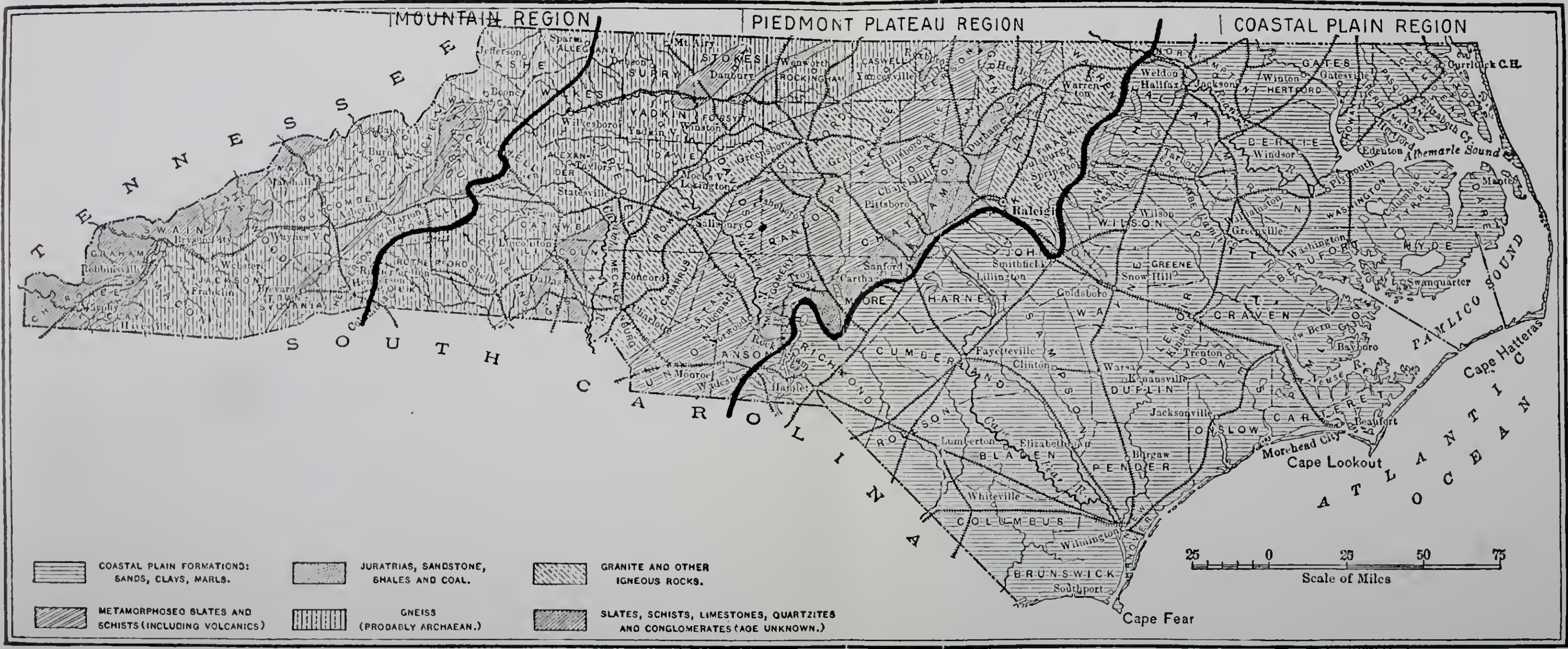


PLATE 1. SKETCH MAP OF NORTH CAROLINA SHOWING THE THREE PHYSIOGRAPHIC DIVISIONS AND THE DISTRIBUTION OF THE PRINCIPAL GEOGRAPHICAL FORMATION

already referred to and what their conservation will mean to this State.

Let us consider briefly the general geographical and geological conditions of the State, as they greatly influence the methods that must be used in conserving our resources. See Plate 1.

As one travels across the State from its eastern shores to its western boundary, it will be noticed that when about half the distance has been passed there is left behind a region which is very level or gently undulating, the surface of which is covered with sand and loam soils from which hard rocks are almost entirely absent; and there is entered another region, the surface of which becomes more and more hilly until it culminates in the high mountains in the western portion of the State, the soil being mingled more or less with hard, granitic, slaty rocks. It will also be noticed that the geological formations of the eastern half of the State are radically different from those of the central portions of the State, which are in turn different from the mountain region.

### PHYSIOGRAPHIC DIVISIONS OF NORTH CAROLINA

There are three great physiographic divisions in the State which have been designated as the Coastal Plain, the Piedmont Plateau, and the Mountain region, whose boundaries in a general way are rather sharply defined.

These three physiographic divisions are indicated in a general way on the map, Plate I.

The Coastal Plain region represents the most recent geologic formations composed of gravels, sands, clays and marls arrranged in nearly horizontal layers with the finer material nearer the coast. Along its eastern borders this region contains the sounds and bays, the sand dunes and ridges, the swamps and marshes, and other characteristics of a seashore region. Further inland it is gently undulating and has more of the upland and less of the marsh; towards its western boundary the swamps disappear almost entirely, the upland predominates and the surface becomes more undulating and even hilly in places. The soils toward the east are composed of fine sand and silt, while nearer the western border of the region they contain a larger proportion of coarse sand or gravel mingled with clay. The extent of this region is from Raleigh eastward to the coast, with its western boundaries roughly defined as extending from the western part of Warren through Franklin, Wake, Cumberland, Chatham, Moore, Montgomery and Anson counties.

Along the western border of the Coastal Plain region there are occasional outcrops of hard granites and slates exposed along the beds of streams, where the once overlying sands and clays have been washed away. In the southeastern counties of this region limestone is exposed at the surface along the banks and streams in a large number of localities. This rock is of such quality that it can in many cases be used for the making of lime, macadamizing roads, and perhaps in some cases for building purposes.

Throughout the entire area of the Coastal Plain region, cotton, corn, oats, sorghum, peas, peanuts, potatoes, especially sweet potatoes, are the staple crops and the culture of tobacco has been introduced with success. Wheat is grown to a considerable extent on the broad lowlands of the Roanoke and in the counties on the north shore of Albemarle Sound; rice has been for a long time a staple crop on the lowlands of the lower Cape Fear; and the upland variety of rice has been introduced with entire success. All the cultivated fruits and berries grow in this Coastal Plain region in great perfection.

The Piedmont Plateau, extending westward from the Coastal Plain region to the mountains, is about 125 miles in width and has an average elevation approximating 900 feet. Crossing the Piedmont Plateau obliquely, are a series of geologic formations which are in general parallel to the mountains and seashore. This section contains undulating lands with many broad valleys and occasionally an isolated mountain ridge or peak. On account of this character of the land, the conservation of the soil is one of the problems of the Piedmont section.

There is a great variety of rocks in this section and consequently the soil of the Piedmont section is very much diversified. This together with favorable climatic conditions, causes this section to have an exceedingly varied range of agricultural products. In this region we find the largest area devoted to the cultivation of the most profitable varieties of tobacco. It is here also that the culture of cotton is more largely extended and pursued and it is in this region that all the cereals and all the grasses are cultivated to their highest perfection. The fruits of this section are unequalled in excellence, variety and abundance.

It is in this Piedmont Plateau region that the great waterpowers of the State are located and their conservation and utilization will be of the greatest benefit to the State in its general industrial advancement. In this region are also the richest and most valuable of the mineral deposits of the State, the development of which, especially of the clay products and building stones for structural materials, should add very largely to the wealth of the State.

The Mountain region includes the Blue Ridge, Great Smokies, and the country between, which is cut across by numerous cross ranges separated by narrow valleys and deep gorges. The average elevation of this region is about 2,700 feet above the sea level, but the summits of many ridges and peaks are over 5,000 feet. A considerable number of peaks (43) reach a height of 6,000 feet or over, the highest of which is Mount Mitchell with an elevation of 6,711 feet. Over the larger part of this region are to be found the older crystalline rocks, gneisses and granites, probably Archean, which are greatly folded and turned on their edges. On the western and eastern borders of this Mountain region approximately along the line of the Blue Ridge and Great Smokies there are two narrow belts of younger rocks consisting of limestones, shales, and conglomerates and the metamorphosed marbles, quartzites and slates. In this region, as in the Piedmont Plateau, the rocks are decayed to a considerable extent and thus have produced deep soils which vary in character according to the rocks from which they have been derived. The soils are for the most part porous and fertile, affording a luxuriant vegetation, in many places the slopes of the mountains being covered by heavy virgin forests. Where the rocks that have decomposed contain a large percentage of aluminous minerals, a large amount of clay has been formed.

The mountains are covered with a rich soil and the forests extend to their tops. There is no area in any of the other states that is covered with such a variety of timber trees and of such value as are to be found in this mountain region of western North

Carolina. These forests formerly contained extensive areas of walnut, poplar, cherry and tulip trees that had attained a size that would hardly be credited by those who had not seen them. Instead of conserving and perpetuating these valuable trees, they have been ruthlessly cut and logged and are now almost completely exterminated. In general, the cultivated products of this mountain region are similar to those of the Piedmont Plateau region, with the exception of cotton and rice. Two products, however, the Irish potato and cabbage, are grown in this region to a degree of perfection that is hardly excelled anywhere. Of fruits, the apples of the mountain region are widely known for their size and flavor. In the northwestern counties of Ashe, Alleghany, Watauga, Mitchell and Yancey, the conditions are favorable for perfect success in cattle raising.

### SOILS

In discussing the conservation of our natural resources, the first that will be taken up will be soils and products of the soil, as forests.

The conservation of the soils and forests stands out preeminently as the most vital duty demanded of us in respect to our natural resources. The nation must be fed and no matter whatever else is given up or destroyed, our food products still remain an absolute necessity and, therefore agriculture really becomes the most important of all human occupations. The worst panic that could be conceived as happening to a nation would be caused by the farmers of the country stopping for but one year the planting and raising of farm products.

Upon the quality and the depth of the soil depends the yield of the farm. With a decrease in the productiveness of the soil, the cost of raising a certain quantity of any kind of produce will increase and this will mean an increase in the cost to the consumer. Thus, both producer and cousumer are very materially affected by the lack of foresight of the producer to keep up the productiveness of his soil to its highest efficiency.

In the early history of the State there may have been some excuse for this, for, with our vast expanse of territory, it was hard

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**PLATE 2.** CHARACTERISTIC EROSION OF THE MICA RED CLAY AND SILT SOILS. VERTICAL WALL GORGES ARE QUICKLY FORMED IN SOILS OF THIS TYPE WHEN UNDERMINING ONCE BEGINS, AND THE FINAL RESULT IS THE COMPLETE DESTRUCTION OF THE SOIL FOR FARMING PURPOSES.

for the people to see or realize the need of seriously considering the question of soil preservation. But, as our population has increased and the productiveness of the soil decreased, the question of soil preservation has become acute.

The first settlers in North Carolina saw in the eastern counties what was apparently an unlimited amount of the most fertile black soil. They considered it inexhaustible, and if the first portion cleared was not perfectly satisfactory, another section would be cleared and the first abandoned. This has also been the principle pursued in respect to the wearing out of the soil. After a certain number of years of constant cultivation, without the addition of any fertilizer, a soil begins to deteriorate and become poor, having given up to the plant certain of its chemical constituents that the plants required for their growth. The old custom has been to abandon such lands and clean up others. This method has also been carried on in the Piedmont and Mountain regions of the State, even up to within the past ten or fifteen years. To-day we are beginning to feel quite seriously the effect of this method of the utilization of our soils.

We have thousands of acres of land scattered throughout North Carolina that are known as "wornout" lands. It is land upon which it is now practically impossible to profitably raise any farm product. These lands not only have had the plant food value almost entirely taken out of the soil but they are in many instances badly eroded and cut into deep gullies, in some instances the entire soil having been washed away (See Plate II). They are really blights on the landscape and very seriously affect the attractiveness of adjacent farms that are in many cases very productive and prosperous.

As can readily be realized from the great variations in the soils of North Carolina, and the great difference in the surface of the land, there must be different methods employed to conserve the soils. Thus, the heavy, red, clayey soils of the undulating Piedmont section will require a decidedly different handling from the heavy, black, loamy soils of eastern North Carolina. In every case consideration must be given to the fact that it is necessary to add to a soil certain chemical constituents in order for it to retain its fertility. This can be accomplished partly by the rotation of crops and partly by the addition of natural and artificial fertilizers. We have not the time to go into a discussion of this phase of conserving the fertility of the soil, but we can simply state the fact that this is absolutely necessary if the soil is to be kept to its greatest efficiency.

*Erosion of soils.**—In the Coastal Plain region, especially the eastern portion, there is but little difficulty in preventing the soils from being eroded and washed away. This, however, becomes a most serious question in the Piedmont and Mountain regions. To prevent this total destruction of the soil is a serious problem and one to which considerable attention has been given by those interested in the conservation of soils. The effect of this erosion and washing away of our soils, is illustrated in nearly every section of the Piedmont region in the form of gullied farms and areas where the decomposed rocks are exposed and but very little of the soil has been left (See Plate III). There are two methods by which this loss of soil can be very materially lessened and in some instances entirely prevented: First, deeper plowing; and second, terracing. The first applies to all land in the Piedmont and Mountain sections and the second to those steeper areas where it is impossible to hold the soil from washing even by circular and ditch plowing. By terracing (See Plate IV, A and B), however, these steeper slopes can be very effectively kept from washing and the soil preserved. This erosion of the hillside farms of the Piedmont section is one of the greatest drawbacks to successful farming and, while it is possible for one to have a good and productive farm on level land, it requires a man of much greater capacity to operate a farm properly under the adverse conditions which prevail in the Piedmont section where hillside farming is practiced.

Let us consider for a few moments the extent of this erosion and the amount of soil that is annually washed from our farm lands. In this section it amounts to more than 4,000,000 tons per year and this has a value based on the amount of plant food and humus in it of approximately $2,000,000. In the heavy floods of 1908, the estimate was made that 1,500,000 tons of soil

*See Bull. 17 N. C. G. S. Terracing of Farm Lands, by W. W. Ashe.

**PLATE 3.** EROSION ON A PIEDMONT HILLSIDE. THE SOIL HAS BEEN REMOVED COMPLETELY IN SOME PLACES AND HAS STARTED VERTICAL GULLIES IN OTHERS.

**PLATE 4a.** A STEEP SLOPE IN PIEDMONT NORTH CAROLINA THAT HAS BEEN WELL TERRACED. ALTHOUGH THE TERRACES ARE NARROW THEY ARE NEARLY LEVEL AND THERE IS BUT SLIGHT EROSION.

**PLATE 4b.** THESE TERRACES, ALTHOUGH WELL LOCATED, ARE TOO FAR APART, THE RISE BETWEEN THEM BEING TOO GREAT. AT LEAST ONE INTERVENING TERRACE SHOULD HAVE BEEN CONSTRUCTED.

were washed from the hills of the Piedmont during one week of rain. These figures are based on actual measurements that have been made at various times on some of our rivers as to the amount of sediment carried down by the rivers in a given time. About one-fifth of this solid matter, which causes the muddiness of the waters during a flood, is humus which is washed chiefly from the hillside farms. Estimating this at $2 per ton, which is probably less than it will cost the farmers to replace it, the loss to them in impoverishment of their soils exceeds $500,000. This is a loss which is much underestimated or entirely overlooked by the farmer because it is a loss which takes place so constantly. In the aggregate, however, it is so enormous that it is one of the chief, if not the chief, reason of the poverty of so many of the red clay, hill-side farms.

Lands which are too steep to be readily *terraced* are too steep to be profitably cultivated and, therefore, should not be cleared, but should be kept in forest. If they are already cleared, steps should be taken to re-forest them.

It is possible, even after a land has become very badly eroded, to reclaim it not for agricultural purposes but for forestry purposes.

To be a successful agriculturist or farmer, requires study and thought; and today all those who have taken up this occupation for a livlihood and who are making the most money are those who give thought to seed sellection, rotation of crops, and the fertility and preservation of the soil. There has been too great a tendency to farm too much land; men not realizing that there is more money in farming a small acreage very well than a large acreage poorly. It costs little or no more to raise forty to seventy-five bushels of corn to an acre than it does fifteen, but the profit is very much greater.

### FORESTS*

The preservation of our forests, which are one of the natural products of our soils, is one of the most important problems that

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*For more detailed information regarding the forests of North Carolina see the following publications of the North Carolina Geological and Economic Survey: Bull. 5, Forests, Lands and Forest Products of Eastern N. C., Bull.

now confronts the State. Before taking up the question of the conservation of the forests, I wish to call attention to the character of these forests and their importance to the State. North Carolina is unequaled in the variety of its hardwoods and conifers by that of any other State or territory. See Plate V. Throughout the whole area of the State the great variety of soils and climate has brought together trees from all parts of Eastern America. There are altogether 153 kinds of woody plants which form a simple upright stem and attain arborescent proportions, growing naturally within the State and of these over 70 are trees of the first size and 57 are trees of great economic value. Plates VI and VII give a good idea of our hardwood and pine forests. Fourteen of these are known to attain in this State a height of over one hundred feet; three of them a height of over one hundred and forty feet; sixteen of them reach diameters of five feet or over; and five, diameters of seven feet or over. There are 24 kinds of oaks found in the State which are three more than occur in any State to the North and two more than are to be found in any State to the South; of the nine hickories known to occur in the United States, eight have been found in North Carolina; here are found all six maples of the Eastern United States, all of the lindens, all six of the American magnolias, three of the birches, eight of the eleven kinds of pines, both species of the hemlock and balsam fir, and three out of the five elms.

The importance of the forests to North Carolina is strikingly shown by the fact that the forests and the industries dependent upon them produce material amounting in value to more than $35,000,000 per year and give employment to 30,000 men. There are but few States in this country where the importance of the forests is relatively as great as in this State where one sixth of the entire wealth-producing capital is invested in forest lands or in industries directly dependent upon the products obtained from the forests. As a State we recognize that our furniture industry is absolutely dependent upon a permanent supply of hardwood; that the tanning industry, if it is to become a permanent one as it should, is dependent upon a constant supply of tanning material,

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6. The Timber Trees of N. C., Bull. 7. Forest Fires, Bull. 16. Shade Trees for N. C.; Press Bulletins 14, 15, 16, 17, 18, 20, 22, 24, 25, 27, 28, 30, 34, 36 and 38, which discuss various questions relating to Forestry.

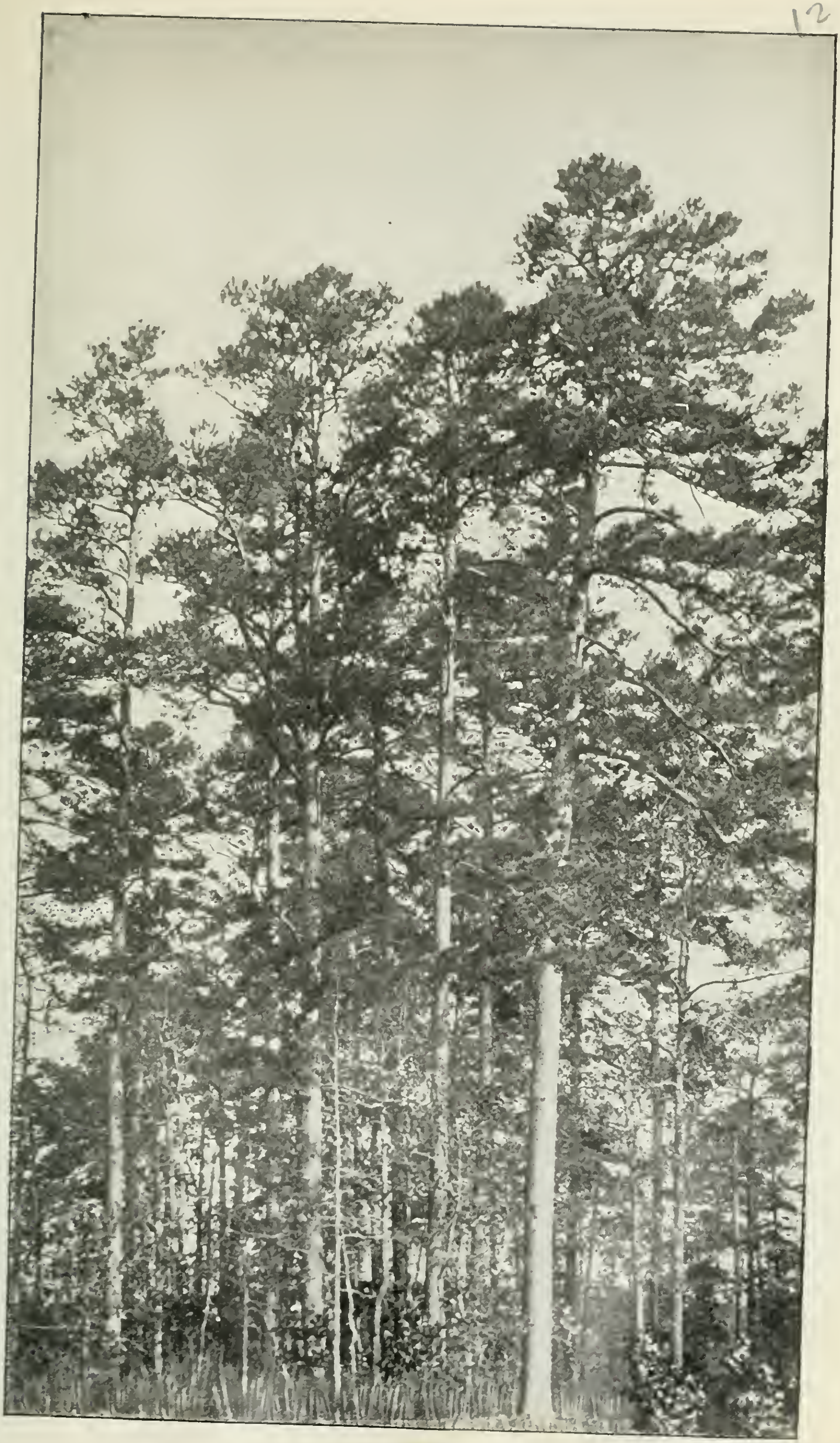

PLATE 5. A MIXED PINE AND HARDWOOD FOREST IN THE PIEDMONT PLATEAU REGION.


PLATE 6. A HARDWOOD FOREST IN T[illegible]OUNTAIN [illegible]N OF NORTH CAROLINA.

PLATE 7. A LOBLOLLY PINE FOREST IN EASTERN NORTH CAROLINA.

as hemlock and chestnut oak bark; and that the paper industry, which also should be a permanent one, is dependent upon a constant supply of pulp wood. I believe that it is not only possible to make these industries permanent in North Carolina and to give them a constant supply of the various woods that they need, but that it is also possible to develop these to a still greater extent. To do this it is necessary that our forests be conserved and perpetuated.

The forest area of North Carolina covers more than 10,000,000 acres, a very large part of which is steep, rough, or poor land unsuitable for farming purposes. There are also about 2,000,000 acres of waste land in the State which have been lumbered and burned or cleared and found unprofitable to cultivate on account of roughness or erosion, which should be re-forested. With this large area of timber land there was no thought given in the early history of the State to the question of a diminishing supply of forest products. Similarly as in connection with the soils, the people of the State considered they had an inexhaustible supply and therefore gave no thought as to how much they wasted in obtaining what they wanted or how much was destroyed by fire. No care was taken in lumbering to preserve seed trees and make it possible for the land to re-forest itself to the best advantage. In lumbering no plan was considered with the end in view of the forests reproducing themselves with varieties of trees as valuable as the ones removed; or that they would maintain a density so that the soil might produce its full capacity; or of even protecting the timber that still remained. Such methods of lumbering have finally brought us to the place where, according to the State Forester, there are more woody materials used or cut each year in North Carolina than the forests are replacing by the formation of new wood. Then again, each year the forests become less capable of producing what is required of them. Their area contracts, less valuable trees take the place of the more valuable varieties which are cut, the soil becomes more impoverished and less able to yield large returns, and the demand for woody materials gradually increases with the increase in population.

These existing conditions demand that some steps be taken immediately to conserve and perpetuate our forests. This conservation means for a great many of our citizens a profitable investment; and, in some instances, as the reforestation of abandoned farm lands, it will mean a profitable investment on lands that are now not producing anything of value.

What the great mass of forest lands now needs, however, more than anything else is adequate protection for young growth, for, unless there is young growth and an abundance of it, there can be no trees to take the place of the old ones when they are cut. If there are 200 mature trees on an acre, there should be, if the same area were in young trees three to five years old, five thousand or more trees. Not one-twentieth of the young trees that start to grow can be expected to become large trees. They are of invaluable service, however, in shading the ground and so keeping it moist that the trees may not suffer from drought in dry seasons; in protecting very young seedlings which may be beneath them from excessive heat or sudden changes of temperature which the seedlings of some species cannot stand; and in forcing those trees which do survive to clear their stems by rapidly pushing their tops upward to get the light, leaving behind on the stems only a few small limbs which soon die and drop off, leaving no knots or knot-holes. The litter of their leaves also forms a rich mould which, as it decays, enriches the soil and stimulates the growth of the remaining trees.

In order to accomplish this, a forest must be protected from fire and also from stock. These forest fires are the greatest menance to the perpetuation of our forests. One of the worst effects of the forest fires in eastern North Carolina has been the prevention of the long-leaf pine from reproducing itself. Large areas that were once covered with this valuable tree and which should now be reproducing another growth of the same kind are instead covered with sand oak or blackjack, which are practically valueless. The loss to the people of this section from the burnings of these pine lands, taken in the aggregate, is enormous, as, but for the burnings, thousands of acres which are now denuded of all merchantable trees would either be covered with mature forests or with thick growths of young trees.

The long- leaf pine (See Plate VIII) which was formerly very abundant in the Coastal Plain region of North Carolina, has been

PLATE 8. A LONG-LEAF PINE FOREST IN EASTERN NORTH CAROLINA.

entirely exterminated in certain sections, and the localities where it now grows have been reduced to a very small area. The lands formerly covered with beautiful forests of long-leaf pine are now covered by small scrub oak, sand oak or blackjack oak which are entirely valueless as timber trees. This failure of the long-leaf pine to reproduce itself is due almost entirely to the frequent fires which year after year in the winter and early spring have devastated the pine woods, killing the young pine seedlings. The long-leaf pine only seeds infrequently, a large seed crop growing about once in five to seven years. The seeds are large and nutritious, and when they fall they are eaten in large quantities by hogs, squirrels, and fowls. Then again after the seed has sprouted and rooted, the seedling is of such slow growth that it is three or four years before it begins to form any appreciable stem, all of its energies being used in growing a deep tap root. This tap root is not at all resinous, but is juicy and nutritious and is dug up and eaten by hogs even when the trees are five or six years old. Thus, even if an area escapes burning, practically all of the young trees are eaten by hogs in those sections where there are no stock laws.

That the long-leaf pine will reseed and reproduce itself, if given an opportunity, is well illustrated in New Hanover county where the stock law has been in force for a good many years, and also some attempt has been made to prevent forest fires. In the vicinity of Winter Park on the road from Wilmington to Wrightsville is a good example of land that has been reseeded in long-leaf pine. All along the track of the electric car line on land, whose chief value at present is apparently in the production of timber, there were long-leaf pine seedlings from one year old up, scattered nearly universally through what was once a solid pine forest; but which years ago was logged off and only a few scattered trees left, which, however, have served for seed trees. This young growth was from one inch to eight or ten feet high and in some places dense enough to eventually form a good forest.

With adequate laws, properly enforced, it would be possible to reforest large areas in the Coastal Plain region of North Carolina in long-leaf pine.

In the counties in the middle part of the State fires have done considerable damage in killing down young growth, but, as a general thing, except where there are large tracts of forest and the country is poor, rugged or thinly settled, the lands are not regularly burned and the damage that has been done to old trees is much less than in other parts of the State. These occasional fires, however, kill much young growth that has been several years growing and in this way keep the woods open.

In the mountains, although there is a great deal of excellent hardwood timber, many of the trees which would otherwise be merchantable have been badly damaged by fire. The woods have been kept free from young growth by pasturage and frequent burnings. In places they are exceedingly open and there are no young trees at all to take the place of the old ones as they are removed.

WATERPOWERS

The destruction of our forests also has a very serious effect upon the waterpowers of the State. There is, perhaps, no natural resource so valuable to the State in connection with her industrial development as her waterpowers. (Plate IX). In central and western North Carolina there are abundant waterpowers, many of which have been most advantageously developed, while others are still unharnessed. Of all the Southern States, North Carolina stands first in the number and magnitude of her available waterpower and when all factors regarding their development and utilization are considered, there is perhaps no State in the Union equal to North Carolina in this respect. The value of these waterpowers cannot be over-estimated. This refers not only to the very large ones but particularly to the great number of small waterpowers from a few to several hundred horse power each, which are to be found on all the small streams in many parts of central and western North Carolina and which are sufficient for the requirements of some local industry (Plate X). They can usually be developed by an individual or company of moderate means and their development and utilization will mean that many small manufacturing establishments will be scattered throughout the State whose operations are independent of any fuel. Many of these waterpowers could not formerly be utilized on account of their location, but now they can be developed and used to advantage by installing at the waterpower an electrical generator and

PLATE 9. THE NARROWS OF THE YADKIN, WHICH WILL DEVELOP 30,000 H. P., ONE OF THE LARGER WATER POWERS OF THE PIEDMONT PLATEAU REGION.

PLATE 10. ONE OF THE SMALLER WATER POWERS OF THE MOUNTAIN REGION, CAPABLE OF DEVELOPING 50 TO 100 H. P.

162

transmitting electrical power to the point of consumption. There are many towns in North Carolina that are now without electric lights or power which could, at a comparatively small expense, obtain the same by the development of waterpowers that are sufficiently large for the purpose and conveniently located. All such development means that a less amount of coal, wood, and other fuels will be consumed for power purposes.

That these waterpowers should be protected, conserved, and perpetuated is acknowledged by all who have investigated them. One of the most vital influences in the preservation of these water powers is the forests and their most noticeable influence is in mountainous and hilly countries, for they, prevent the soil from being washed away and, by the decay of their leaves, form loam which prevents the water from running off the surface too rapidly. By the removal of the forests there is no longer a protection for the soil on the slopes of the mountains and hills except that produced artificially in the form of ditches, etc. There is no longer a layer or bed of leaves to act as a conserver of the water by absorbing it and preventing its too rapid evaporation and it runs off for the most part as fast as it falls, causing high freshets and floods and periods of extreme low water; causing the streams and rivers to be higher at times of floods but very much lower the greater part of the time than they were before the removal of the forests.

The defects in the water supply are not due to the lack of rain but to the removal of the natural agencies that nature has provided for the storing of this water which has resulted from the removal of the forests. Again, these defects are not due to any considerable extent to the clearing of land for farming purposes for the farmer must of necessity protect the soil from being washed away, and the only loss to the water supply that he would cause would be the greater evaporation to which it would be exposed. They are, however, due to the wasteful and destructive removal of the forests by the lumber companies who leave large tracts of land stript in some cases of every vestige of a tree.

It has been estimated that there are available in the United States 50,000,000 water horsepower, but whether this be 50,000,-

000 or 150,000,000, the fact that it exists today is no guarantee that it will exist 20 years from now unless we as a State and a Nation take the necessary steps to preserve this valuable asset. Simply because we do not desire to avail ourselves of all this water horsepower at the present time does not release us from the obligation of preserving the balance of the waterpower for future generations. There is probably no section in the country where waterpower is not cheaper than steam power, although there are certain places where coal is so cheap that the cost of steam power exceeds little if any the cost of waterpower. In other places, however, the waterpower may be as much as $60 per H.P. cheaper than steam power.

We are using at the present time in the United States not less than 26,000,000 steam horsepowers for manufacturing, lighting, railways, etc. Some of this is so situated that it could not at present be replaced by hydro-electric power; but it has been estimated that ten per cent. would cover all the power that could not be readily replaced with hydro-electric power. This would leave 23,400,000 steam horsepowers that could be replaced by hydro-electric power. The average excess of cost of the steam power as compared with hydro-electric power is at least $12 per H.P. This would make a total of about $281,000,000 that the people of the United States are spending annually for power that is in excess of what is necessary to give them the same amount of power. It also means that we are using up each year a very large amount of our coal resources to develop this power which could just as well be produced by waterpower.

Although at the present time our waterpowers are not being developed to the extent that they should be, yet the amount of hydro-electric power that is being used each year is constantly increasing and the increase in the price of fuel which is bound to come will cause the waterpower development to increase much faster. In studying conservation and its relation to power development, one thing should be taken into account and that is that by proper conservation our waterpowers can be made perpetual and give a constant supply of power: while, on the other hand, when fuel is used to develop the power, it is a constant drain on our

**PLATE 11.** GENERAL VIEW OF THE MOUNT AIRY GRANITE QUARRIES SURRY COUNTY, NORTH CAROLINA.

fuel resources and the power developed is limited to the amount of fuel used. Thus, every water horsepower developed and utilized means just so much conserving of our fuel resourcss, which, when once used, cannot be replaced.

### MINERAL PRODUCTS

The conservation of the mineral resources of North Carolina is not as serious a problem as it is in many of the States inasmuch as we have no supplies of coal, oil or iron of any great commercial importance at the present time. Of the metal iron, we have deposits of considerable extent which will be available and of large commercial value sometime in the future, but at the present time their isolation from sources of fuel, flux and market are conserving them without any assistance from the State. (See Plate XI) Our structural materials, such as building stones and clay products, as brick, terra cotta. etc., should be developed on a larger scale than they are at the present time, for by their development and utilization we will reduce the drain upon our timber building products. While there is more or less waste in quarrying building stone (See Plate XI.), still many of our companies have found uses for a great deal of what was formerly waste product. Thus, a good deal of the stone that does not make good building material is cut into curbing, into blocks for paving streets, and crushed stone for reinforced cement work, and for macadamizing roads. These products should, therefore, be utilized just as much as possible, and, while we are not in one sense conserving them, we are, as stated above, conserving one of our other natural resources (timber), the drain upon which is now almost equal, if not equal, to the growing capacity of the forests.

### SWAMP LANDS

Another line of conservation that I wish to mention briefly is the reclamation of swamp lands. In the western part of the United States the reclamation of these waste lands comes under the head of irrigation, while in the eastern portion of the country it comes under the head of drainage. Irrigation is bringing to land the water that it requires to make it adapted to raising crops while drainage is taking off and away from the land the excessive amount of water that prevents the land from growing a crop. The Federal Government has already spent many millions of dollars in the reclamation of the dry, arid lands of the West and have been most successful in this work, causing large areas of the desert lands to become flourishing farms. Attention now is being called to the reclamation of our swamp lands and it is considered just as important that such land should be reclaimed as that the arid lands should be watered. We have in North Carolina approximately 4,505 square miles or 2,883,000 acres of swamp lands, besides thousands of acres of overflowed lands, many of which are susceptible to reclamation if properly drained. This area of swamp land in North Carolina is nearly as great as that of the Kingdom of Saxony, which has nearly 5,000,000 people. Thus it is seen that the State has the opportunity of developing an area which is capable of supporting a population that is considerably larger than the population of the whole,State.

The approximate amount of swamp land in 28 of the eastern counties in North Carolina is as follows:

| County | Square Miles | County | Square Miles |
|---|---|---|---|
| Beaufort | 177 | Hyde | 387 |
| Bertie | 57 | Jones | 139 |
| Bladen | 192 | Martin | 86 |
| Brunswick | 300 | New Hanover | 25 |
| Camden | 162 | Onslow | 134 |
| Carteret | 126 | Pamlico | 325 |
| Chowan | 80 | Pasquotank | 80 |
| Columbus | 300 | Pender | 370 |
| Craven | 238 | Perquimans | 92 |
| Cumberland | 30 | Pitt | 40 |
| Currituck | 40 | Robeson | 130 |
| Dare | 344 | Sampson | 118 |
| Duplin | 125 | Tyrrell | 251 |
| Gates | 45 | Washington | 262 |

Total, 4,505 square miles, or 2,883,200 acres.

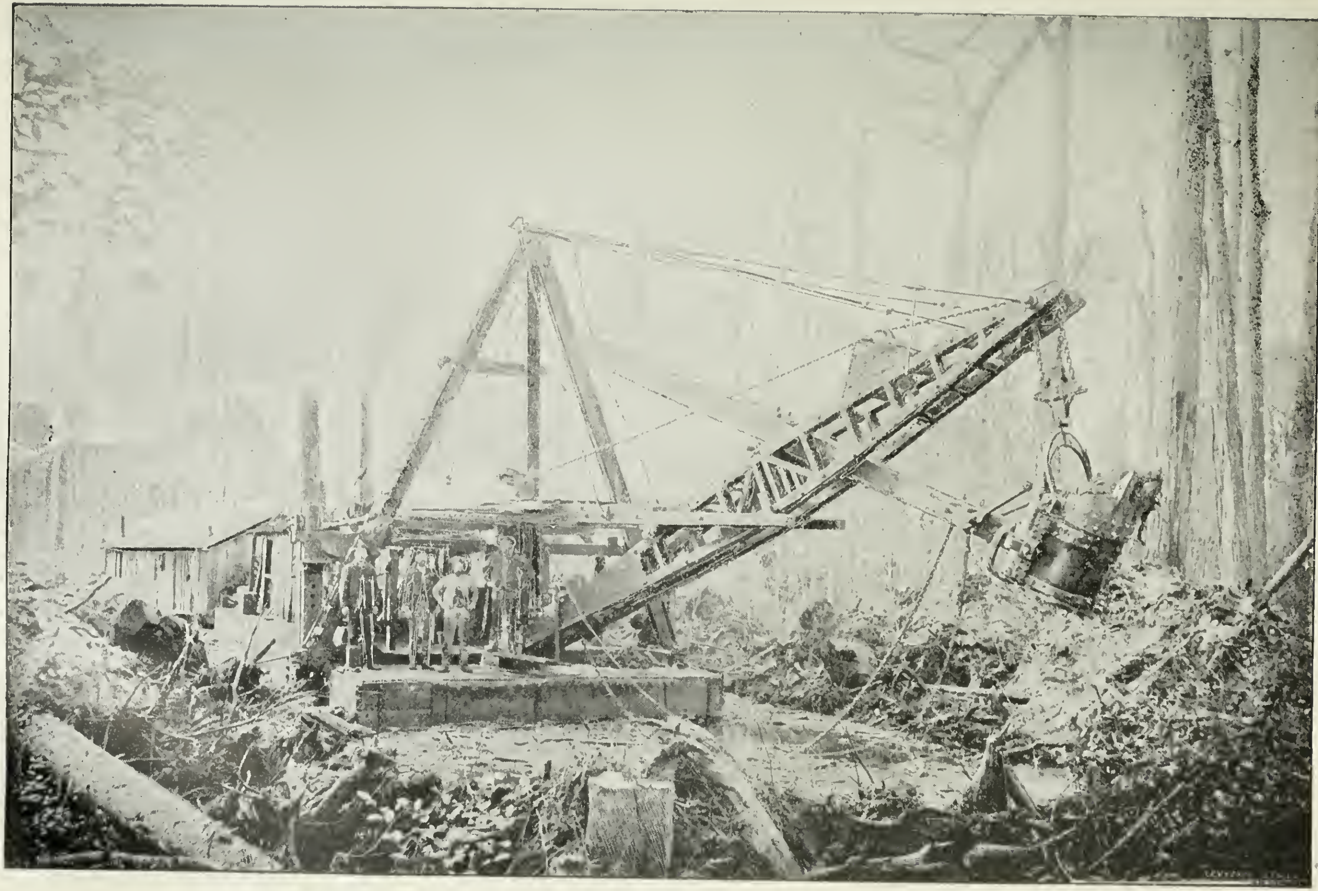

PLATE 12. CHARACTERISTIC SWAMP OF EASTERN NORTH CAROLINA. SHOWING DREDGE AT WORK CUTTING A DRAINAGE CANAL.

DRAINAGE OF SWAMP LANDS

Considerable work has been done by the Geological and Economic Survey in cooperation with the Drainage Division of the United States Department of Agriculture in investigating:

1. The character of the swamp, whether the soil is suitable for agricultural purposes.

2. Whether the swamps and overflowed lands, where suitable for agricultural purposes, could be profitably drained.

3. Whether the peat deposits contain sufficient quantity of this material and of such quality that it could be marketed.

In making these examinations and in interviews with the people living in this section of the State and interested in the reclamation of these swamp lands, it was found that three obstacles had formerly stood in the way of the drainage of these swamp lands: (1) the cost of clearing the land; (2) the excessive cost of digging adequate canals and ditches to take care of the water; (3) the lack of an adequate law that would permit the carrying out of drainage propositions.

Now, however, all these obstacles have been removed and, wherever the land has sufficient agricultural value to warrant drainage, the drainage propositions can be carried out successfully. Plate XII, shows a swamp in eastern North Carolina, with dredge at work cutting a drainage canal.

The drainage of this vast swamp area would mean not only additional wealth to the State, but it will mean improved roads through large areas that are now almost impassible and inaccessible; the improved roads will mean better school facilities for the children. The drainage of the swamps will also greatly improve the heathfulness of this section of the State.

Of the 3,000,000 acres of swamp land, at least 1,225,000 acres are of sufficient agricultural value to warrant their being drained and are sufficiently elevated above the neighboring water courses to make their drainage a feasible proposition.

The drainage act passed by the State Legislature of 1909 makes it possible to carry out any large drainage proposition, and, as a result of the passage of this aet, there are now 16 drainage districts formed or in process of formation, which embrace approximately 350,000 acres.

The fertility of the soil of these swamp lands is unsurpassed, and sufficient work has already been done by soil surveys and the cultivation of the land that has been reclaimed to demonstrate that taken as a whole it is preeminently a corn soil. At the present time, North Carolina produces 2.7 per cent. of the entire corn crop of the United States, but, if these swamp lands were thoroughly drained and properly cultivated, they alone could produce a crop of corn that would be equal to 10 per cent. of that raised in the United States during the past year.

As an illustration of the value of some of our swamp lands after they have been drained, I would like to state what has actually taken place during the past year at one locality in North Carolina. About five miles southeast of Pinetown, Beaufort County, a canal has been constructed through one of our large swamp areas for a distance of five miles and has a width of 30 feet and depth of 7 feet. Before this canal was begun the people living in the vicinity of the swamp all claimed that it would be impossible to drain the swamp, as there was not sufficient fall to take care of the water. The men who were interested in the project, however, had had a survey made of the swamp and were confident that there was sufficient fall along the line of the canal to take care of all the water and drain the land. As the canal was being constructed, it was found necessary at the end of a mile and a few yards to construct a retaining dam six feet high in order to keep sufficient water in the canal to float the dredge. After another mile and a quarter of the canal had been constructed, it was found necessary to build another dam six feet high. After the five miles of canal had been constructed, the total fall in that distance was found to be a little over 12 feet. The dredge was then taken back down the canal and the dams removed. During the extreme heavy rains of the summer of 1908 in eastern North Carolina, this canal was able to take care of all the excess of water, and, as far as I could ascertain, it never rose over 12 inches in the canal. In order to determine the actual agricultural value of the land drained, 10 acres bordering on the canal were cleared by cutting down the trees and underbrush and burning them, but leaving the stumps. Corn was planted by means of a hand-drill made out of a piece of hollow gum wood. There was no opportunity for plowing the field, so the corn was planted by simply running the drill into the ground and dropping the seed. It was also impossible to cultivate the corn as it was growing, on account of the stumps. The fires, however, had destroyed all of the undergrowth, so that there were no weeds to interfere with the growth of the corn. This tract produced an average of 40 bushels of corn to the acre, and this will give an idea of the great value of this land for agricultural purposes. With the construction of lateral canals this main canal will be capable of of draining from 6,000 to 7,000 acres.

Even the land that is now under cultivation also needs a certain amount of drainage, principally due to the fact that the swamps becoming full of water overflow and saturate the cultivated land with water, so that during the past eight or ten years the farmers have not been able to secure but one good crop in three, with the result that a great many have had to abandon farming. Hyde County, which was formerly known as the granary of eastern North Carolina, was for three years prior to 1909 literally drowned out, but during the latter year there was just the right amount of rain at the right time, so that the crops were excellent. With drainage of the swamp lands of Hyde County, they could be practically assured of a good crop each year, which would mean that this county would be capable of becoming one of the richest counties in the State. Nearly all the other counties in eastern North Carolina have suffered in the same way from lack of drainage; but, operating under the Drainage Act of 1909, these conditions will in a few years be changed and eastern North Carolina will become one of the most prosperous agricultural sections of the country.

In certain portions of these swamps there are deposits of peat which may become sources of a supply of fuel. A small amount of work has been done towards testing these peat deposits, their area and locality, and, while not enough information has thus far been obtained to warrant a definite statement relating to these deposits, yet, we do know that there are certain areas, as the peat bog on the outskirts of Elizabeth City, which contain a good quality of peat which could be used as a fuel in the form of briquettes. Some of these peat deposits are located in close proximity to small towns, and it is very probable that it would be practicable to erect an electric plant at the bog using the peat as a fuel, either in the form of briquettes under a boiler, or using the peat directly in a gas producer, and producing electric power which could be transmitted to the town. The utilization of peat in this way would be another means of conserving our other fuel supplies of coal and wood.

### FISHING INDUSTRIES

Usually, in discussing the subject of conservation, we are not apt to realize, at first thought, that it applies to the protection and perpetuation of our fish, oysters, and other products of the sea just as much as to the protection of the natural resources of the land.

There is no doubt but that the supply of edible fish, clams and oysters in the waters of North Carolina is becoming less and less each year. There are two facts that are responsible for this condition: (1) insufficient laws for the protection of fish and oysters; (2) non-enforcement of the laws that have been passed.

The falling off in the catch of edible fish is not due to the use of any particular kind of apparatus but to over fishing and the permitting of the fishing of apparatus in places where it ought not to be used. Hundreds and thousands of small fish have been caught, which, if permitted to remain in the water, would in a year or two have become valuable edible fish. The small fish caught in this way are often dumped on the shore and used as fertilizer or shipped to market, with a faint hope that they may be marketable, but often they are thrown out by the dealer. If the small fish are destroyed (by whatever means), it is a self-evident fact that there will soon be a scarcity of large ones, and finally certain fish will become extinct in the waters of North Carolina.

It is possible to protect and perpetuate our fish and oyster industries by the enactment and enforcement of adequate laws. I believe that the only adequate method of enforcing state laws and fostering our fishing industries is through the operation of a Fish Commission. The work of this commission should be not only to see that the laws are enforced, but it should be able to carry on investigations relating to the various fishing industries; to study local conditions and be able to render a just decision regarding what is the best thing to be done in relation to the perpetuation of the oyster and any type of fish, to the best interests of the state. Up to the present time these questions have been considered locally, while they should be considered as state questions, and the best results can only be obtained when they are thus considered.

The North Carolina Geological and Economic Survey has, and is still, carrying on investigations relating to the protection of the fish and oyster, and to the cultivation of the oyster and clam. The result of this work has been the establishment of a fish commission, but whose jurisdiction, however, is only over a portion of the state; and the passage of an act by the Legislature which makes possible the cultivation of the oyster in North Carolina.

In the investigations relating to the cultivation of the oyster a variety of bottoms as the waters of Pamlico Sound were tested by plants, as at Cunning Harbor, Pains Bay, Long Shoal, Bight of Royal Shoal, and the Junction of Pamlico and Core Sound.

The investigations of the Survey have proved rather conclusively that the cultivation of the oyster is practicable and profitable; and further. that the future of the oyster industry in North Carolina is dependent upon the development of the industry of oyster culture.

# THE BROMINATION OF ANTHRANILIC ACID*

BY ALVIN S. WHEELER AND W. M. OATES

The monobromaminnobenzoic acids have been prepared in most cases by the reduction of the bromnitrobenzoic acids in acid solution with tin, zinc or stannous chloride. The 5-bromanthranilic acid was obtained in two other ways by Alt[1] viz., (1) by the oxidation of 5-brom-acettoluide by potassium permanganate and (2) by the bromination of acetanthranilic acid. The latter reaction was conducted in aqueous and in acetic acid solution, the only product isolated being the monobromanthranilic acid. We find that in brominating anthranilic acid direct in acetic acid solution at as low a temperature as possible that one third of the product consists of the 3, 5-dibromanthranilic acid. We[2] find it a most excellent method for preparing both acids. Bogert and Hand[3] employed Alt's methods.

The dibromaminobenzoic acids have been prepared similarly. In addition Wachendorff[4] heated o-nitrotoluene with bromine at 170°. Bogert and Hand[5] prepared 3, 5-dibromanthranilic acid by treating a dilute hydrochloric solution of anthranilic acid with a mixture of potassium bromide and potassium bromate. No yield is given. The few tri- and tetraaminobenzoic acids which have been described were obtained by the action of bromine upon the amines or anil.

We have studied the action of bromine upon anthranilic acid in glacial acetic acid solution, (1) near the freezing point and (2)

*Contribution from the Chemical Laboratory of the University of North Carolina.

1 Alt, Ber. d. Chem. Ges., **22**: 1645. 1889.

2 Wheeler and Oates, Journal American Chemical Society, **31**: 568. 1909.

3 Bogert and Hand, Journal American Chemical Society, **27**: 1476. 1905.

4 Wachendorff, Ann. Chem. (Liebig), **185**: 281.

5 Bogert and Hand, Journal American Chemical Society, **25**: 935. 1903.

near the boiling point of acetic acid. In the first case two thirds of the product consists of the 5-bromanthranilic acid and one third of the 3, 5-dibromanthranilic acid. Under the other conditions the results are reversed almost exactly. The two acids are readily separated by boiling water in which the dibromanthranilic acid is nearly insoluble. The separated acids may be brought upon drying plates within an hour after the preparation is begun.

The monobromanthranilic acid is converted by short boiling with acetic anhydride into the anil and the latter on treatment with water is very rapidly hydrolyzed to bromacetanthranilic acid. Bogert and Hand prepared the anil by boiling the bromacetanthranilic acid with acetic anhydride. We found the barium salt to contain four molecules of water as did Alt. The salt obtained by Bogert and Hand was anhydrous. We have prepared also the silver salt, ethyl ester, 2-chlor-5-brombenzoic acid and its barium salt. The latter acid has only been described by Cohen[1] but he gave no analysis. Our preparation recrystallized from glacial acetic acid gave the melting point stated by Cohen, 155-6°, but we could get no satisfactory analysis. Then on recrystallizing from water we raised the melting point ten degrees. In view of this discrepancy we shall postpone the description until we have made the acid by Cohen's somewhat tedious method. In this paper we also describe the anil and acetyl derivative of the dibromanthranilic acid as well as the silver salt and ethyl ester.

### *5-Brom-2-aminobenzoic Acid*

*Brominatian of anthranilic acid below the freezing point of glacial acetic acid.* Twenty grams of anthranilic acid were dissolved in 250 cc. glacial acetic acid and cooled below 16°. After 9.5 cc bromine had been run in the reddish color of the liquid persisted. Before this point was reached the mixture had been converted into a thick mush of white glistening crystals, consisting of the hydrobromides of the mono- and dibromanthranilic acids. The product was filtered off, washed with benzene and after drying was found to weigh 54.7 grams. It was then boiled up with 500 cc. water containing 25 cc. concentrated hydrochloric acid and filtered hot

1 Cohen, Journal London Chemical Society, 85: 1267. 1904.

with suction. The insoluble residue was extracted twice more with 500 cc. boiling water. The filtrates upon cooling yielded abundant precipitates of the monobromanthranilic acid. The insoluble residue consisted of the dibromanthranilic acid, amounting to one third of the product. In the glacial acetic acid filtrate we found a little tribromaniline. We also tried the bromination of the hydrochloride of anthranilic acid in glacial acetic acid and also a hydrochloric acid solution of anthranilic acid but the results were less satisfactory.

*Barium 5-brom-2-aminobenzoate.* Alt who prepared this salt by boiling the acid with barium carbonate states that it crystallizes with four molecules of water. Bogert and Hand did not obtain this salt but an anhydrous one crystallizing in prisms. We employed Alt's method and obtained the same salt crystallizing in needles and containing four molecules of water. It was impossible to determine the water since the salt began to decompose before the requisite amount of water was expelled. This occurs about 170°.

| | | |
|---|---|---|
| Calculated for $C_{14}H_{10}O_4N_2Br_2Ba.{}_4H_2O$ | Ba. 21.48 | |
| Found: | 21.78 | |

*Silver 5-brom-2-aminobenzoate.* The neutral ammonium salt was treated with silver nitrate which caused a dense white precipitate. The salt is anhydrous.

| | | |
|---|---|---|
| Calculated for $C_7H_5O_2NBrAg$: | Ag. 33.43 | |
| Found: | 33.69 | 33.51 |

*Ethyl 5-brom-2-aminobenzoate.* The silver salt was boiled with an excess of ethyl iodide. After distilling off the excess the residue was extracted with chloroform. The ester crystallizes from alcohol in yellow needles which melt at 187°.

| | | |
|---|---|---|
| Calculated for $C_9H_{10}O_2NBr$: | Br. 33.10 | |
| Found: | 32.79 | |

*5-Bromacetanthranil.* Bogert and Hand obtained this anil by boiling the 5-bromacetanthranilic acid with acetic anhydride[1]. We obtained it by boiling 4 grams 5-bromanthranilic acid with 40 cc acetic anhydride for 15 minutes. On cooling the solution an abundant crystallization of colorless scales took place. The filtrate contained a mixture of the anil and the acetyl derivative. The anil is very soluble in hot benzene, alcohol and ligroin but difficulty soluble when cold. It is not readily soluble in ether. It melts at 134°. Bogert gives 131° (corr.). It is instantly hydrolyzed to the bromacetanthranilic acid by hot water. The same result is obtained by boiling with glacial acetic acid, 99-100 per cent, for two hours.

| | | | |
|---|---|---|---|
| Calculated for $C_9H_6O_2NBr$: | C, 45.00 | H, 2.50 | Br, 33.36 |
| Found: | 45.00 | 2.62 | 33.40 |

*3,5-Dibrom-2-aminobenzoic Acid.*

*Bromination of anthranilic acid in boiling glacial acetic acid.* Fifty grams of anthranilic acid were dissolved in 500 cc glacial acetic acid and while boiling 27.5 cc bromine were run in. An abundant separation of colorless crystals took place. After cooling the product was filtered off, washed with glacial acetic acid and then with benzene. The weight of the hydrobromides was 116 grams. The mixture was boiled up five times successively with 500 cc water, each filtration being made rapidly with suction. The insoluble residue consisting of the dibromanthranilic acid constituted two thirds of the product. The pure acid was obtained by recrystallizing from alcohol. The melting point was 232° (uncorr.). Bogert and Hand give 235-5.5° (corr.).

*3,5-Dibromacetanthranil.* Ten grams 3,5-dibromanthranilic acid were boiled 15 minutes with 100 cc acetic anhydride. Upon cooling an abundant mass of long colorless needles were deposited, some being an inch long. The weight was nine grams and the melting point 176°, the substance being pure. On concentrating the filtrate another gram was obtained, melting at 173°.

| | |
|---|---|
| Calculated for $C_9H_6O_2NBr_2$: | Br. 50.14 |
| Found: | 49.99, 49.99 |

The anil is easily soluble in benzene, glacial acetic acid, chloroform, toluene and fairly soluble in alcohol. It is insoluble in water, cold or hot. Its conversion back to the dibromanthranilic acid is effected by warming in 15 per cent. sodium hydroxide for 15 minutes and neutralizing with acid. A one per cent solution

1. Bogert and Hand, Journal American Chemical Society, 27: 1484. 1905.

of sodium hydroxide introduces water into the anil giving the dibromacetanthranilic acid.

*3,5-Dibromacetanthranilic acid.* The free acid was obtained by boiling the anil a moment in dilute sodium hydroxide and immediately acidifying with hydrochloric acid. It is also obtained by long boiling with glacial acetic acid. The crude product melts at 217°. On recrystallizing from alcohol-benzene the melting point is raised to 218-9°. It crystallizes from glacial acetic acid in microscopic needles. It is easily soluble in alcohol and glacial acetic acid. It is insoluble in ether, chloroform, benzene and toluene.

| | |
|---|---|
| Calculated for $C_9H_7O_3NBr_2$; | Br. 47.47 |
| Found: | 47.36, 47.42 |

*Silver 3,5-dibrom-2.aminobenzoate.* A neutral ammonium salt solution of the acid was treated with silver nitrate. A dense white precipitate was thrown down. This is anhydrous and decomposes about 270°.

| | |
|---|---|
| Calculated for $C_7H_4O_2NBr_2Ag$: | Ag. 26.84 |
| Found: | 26.70 |

*Ethyl 3,5-dibrom-2-aminobenzoate.* The ester was prepared by boiling the silver salt with excess of ethyl iodide. After distilling off the unused ethyl iodide the residue was extracted with cold chloroform. The chloroform extract on evaporation to dryness left a white but somewhat oily residue. This was recrystallized from alcohol. It forms fan-shaped groups of needles which melt at 74°

| | |
|---|---|
| Calculated for $C_9H_9O_2NBr_2$: | Br. 49.53 |
| Found: | 49.34 49.46 |

Chapel Hill, N. C.
March 19, 1910.

# A VISIT TO THE GRAVE OF THOMAS WALTER*

BY W. C. COKER

**With Plates 13 and 14**

And Bahram, that great Hunter—the Wild Ass
Stamps o'er his head, but cannot break his Sleep.

It has been said that one man cannot make an atmosphere, and this is true, but there will sometimes appear a man with so great "a light within his own clear breast" that he looks out upon the obscure world about him with a soul that is illumined.

Such an one was Thomas Walter, "Agricola," and Botanist of South Carolina.

The lack of the historical instinct which is so characteristic of our people, is sadly evident when we look for the life story of this remarkable student of nature. The little that is known of his life has recently been published in one of the interesting series of articles on South Carolina Botanists by Wilson P. Gee in the News and Courier. It is but the barest outline that we have of his career, and no portrait is extant to give us an idea of his personal appearance.

The fragmentary data we have is gathered from a very few sources, the inscription on his grave; the pages of his book (the Flora Caroliniana); the genealogical record of his descendants, and the traditions of his home community. The pamphlet entitled "A Contribution to the History of the Hugenots of South Carolina," by Samuel DuBose and Frederick A. Porcher (being a republication of several papers) contains most of what is known of Walter's life. From this source was obtained also most of the information given below in regard to the history of the Santee section.

From all sources we learn that Walter was born in Hampshire, England, came to South Carolina as a young man, married Miss Sarah Peyre for his first wife and Miss Dolly Cooper for his second, acquired a plantation on the banks of the Santee River, in St. Steven's Parish, and made it his home for the remainder of his life. His house was built within a few feet of the southern

*Published in part in the Charleston News and Courier, Sunday, March 17, 1910.

edge of the wild swamp of the Santee river, and adjoining it he marked out and planted with paternal care, one of the first Botanical Gardens of America. John Bartram, of Philadelphia, had established the first American Botanical Garden about 1730, and Humphrey Marshall had begun his garden, also near Philadelphia, in 1773, about the time, presumably, that Walter was at work on his. These three gardens were the first of their kind in the United States.

But Walter did not confine his botanical interest to his garden. In complete isolation from the scientific world and seeing, so far as we know, no other person that was interested in science except the itinerant collector John Fraser, of London, he began a scientific study of the plants around him and completed, before his untimely death at about forty-eight, one of the most complete and accurate works on American Botany that appeared during the 18th century. This book, the "Flora Caroliniana," was published in London in 1788, at the expense of John Fraser, the collector and seedsman above mentioned, who had gotten the manuscript from walter on one of his earlier visits to South Carolina. The foot of the title page is inscribed as follows:

Londini:

Semptibus J. Fraser:

Prostant venales apud J. Wenman, in vico vulgo dicto Fleet Street

M,DCC,LXXXVIII

The volume, which is written entirely in Latin, contains 263 pages exclusive of the preface of four pages, index, title page, and dedication page. There are 435 genera, and many of the species described were new to science. In spite of the vicissitudes of botanical nomenclature the names that Walter gave his discoveries are still in large measure retained, and the designations of many of the best known and most attractive of South Carolina plants now honor his achievement and commemorate his name.

Such for example, are: Quercus pumila (dwarf oak), Quercus lyrata (overcup oak), Carpinus caroliniana (hornbeam), Pinus glabra (spruce pine), Nyssa biflora (black gum), Acer Carolinianum (Carolina red maple), Ilex myrtifolia (myrtle-leaved holly), Ilex decidua (deciduous holly), Lilium Catesbaei (Catesby's lily), and Sarracenia minor (a pitcher plant).

Of the plants that have been named by others for Walter, in appreciation of his scientific attainments, the best known, perhaps, is the beautiful red-berried smilax or cat brier (Smilax Walteri) that is abundant in the swamps of our coastal plain. What more charming memorial could one desire than the lovely wreaths of this cardinal of the woods that brighten the cold swamps with such a glowing flame? Every Christmas, at our home in Hartsville, we go out into the swamp and bring in these brilliant berries to add color to the day.

From the last paragraph of the preface we gather that the plants described in the Flora Caroliniana were all collected within a radius of fifty miles, presumably with Walter's home as a center. The paragraph is as follows:

Stirpes plus mille hoc opere comprehendi mirum fortasse videatur, quum cognitum fuerit vix non omnes collectas fuisse ex area non ampliore quam quae linea bis duplicata quinquaginta millium passum circumscribi potest. Etiam multae adhuc latent ut quotitie docet experientia. Gramina et plantae classi Cryptogamiae appertinentes, plerumq. intacta remanent. Praeterea plures omittuntur arbores, frutices et herbae, quorum fructificatio auctori nondum satis patuit.

Carolinae Meridialis,
ad Ripas Fluvii Santee,
30 Dec. 1787.

After the death of Walter in 1780, his plantation became a part of the estate called Mexico, and was for a long time owned by the Porcher family. It is now the property of the Atlantic Coast Lumber Co. of Georgetown.

The herbarium that Walter made was taken to England by John Fraser and seems to have remained in the Fraser family for a long time. In 1849 it was given to the Linnaean Society and was sold by it to the British Museum. It is now to be found in the Natural History section of the British Museum, South Kensington, London.

In an article on the "Identification of Walter's grasses" in the Annual Report of the Missouri Botanical Garden for 1905, Dr. A. S. Hitchcock says:

"The herbarium suffered before it came into the possession of the Museum and many of Walter's types are missing, especially among the grasses. The plants are mounted in a large book, usually several specimens on a page, the labels being fastened to each plant. The specimens are for the most part very fragmentary, often consisting of a leaf or an inflorescence. When the herbarium was obtained by the Museum, most of the plents were mounted, but a few were loose and have been subsequently mounted at the end, following the others. All the grasses appear in this second part (pp. 112 et seq.). There are 18 specimens of the grasses. In the following notes I have attempted to identify the species of grasses published by Walter in his Flora, considering the specimens in his herbarium, the descriptions, which are often meagre, and tradition as shown by the disposition made of his species by Micheux, Pursh, and Elliott, who worked over the same territory and must have been familiar with Walter's work.

"Walter seems to have followed in his identifications the second edition of Linnaeus' Species Plantarum or the twelfth edition of the Systema, which is about the same. The use of italics for cer-specific names is not clear. Those thus printed appear to be new species, but many of those printed in Roman are also new names. Many of Walter's names as applied to grasses are yet doubtfully identified or entirely unidentified and probably must remain so."

The numerous descendants of Thomas Walter are now represented in several prominent family names, but, as his only son died unmarried, the name of Walter was not perpetuated.

He married first Miss Sarah Peyre, of St. Steven's parish, and one son, Thomas, and two daughters, Ann Peyre and Mary, were born of this union. His second wife was Miss Dorothy Cooper and to her another daughter, Emily, was born. The gifted botanist and physician Dr. Erancis Peyre Porcher, well known as the author of the "Resources of our Southern Fields and Forests," was a great grandson of Walter's, and from Dr. Walter Peyre Porcher, of Charleston, his son, and Judge Walter G. Charlton, of Savannah, and Mr. John Peyre Thomas, Jr., of Columbia, I have secured the following record of the descendants.

Thomas Walter, Jr., reached maturity, but did not marry, and died before his father.

Mary Walter married Francis Peyre and had three children, Isabella Sarah, Thomas Walter, and Hannah Ashby, the two latter dying unmarried.

Isabella Peyre married Dr. William Porcher and had six children, William E., Francis Peyre (Physician, and author of "Resources of our Southern Fields and Forests"), Julian H., Louise, Mary, and Alexander.

Dr. Francis Peyre Porcher married Miss Virginia Leigh and had three children, Walter Peyre (Physician, of Charleston), Julia W. (Mrs. T. S. Wickham, of Henrico County, Virginia,) and Virginia L.

Alexander Porcher married Miss Margaret Faber and had one son, Mr. J. Faber Porcher, of Charleston.

Ann Peyre Walter married Mr. Hazel Thomas, of Betaw plantation on the Santee River, and they had issue as follows: Anna Hazell, who died unmarried, John Peyre, Thomas Walter, Edward, Thomas Hazell and Samuel Peyre. Of the sons, all except Thomas Hazell married and left numerous descendants. Colonel John Peyre Thomas, now seventy years old and one of the most distinguished citizens of Columbia, is the son of John Peyre.

Emily Walter married Judge Thomas Usher Pulaski Charlton from the neighborhood of Camden, and had three children, two of whom, Thomas Jackson and Robert Milledge, survived infancy. Dr. Thomas Jackson Charlton married Sarah Waters and had two children, Dr. Thomas Jackson and Ellen St. Leger. This Dr. Thomas J. Charlton married and had several children, among them the present Dr. Thomas J. Charlton of Savannah, who is married and has a son, Thomas J. Jr.

Robert Milledge Charlton married Margaret Sheik, of Savannah and had ten children, of those reaching maturity only the following three have married: Mary Marshal to Julian Hartridge, Mararet to C. P. Hansell, and Walter Glasco (now Judge of the Superior Court, Savannah) to Mary Walton, daughter of Richard Malcom Johnston. All of these have children.

The only published records we have of visits to the home of Thomas Walter, describing the condition of his garden and grave, are by Mr. H. W. Ravenal, the famous botanist, in the Proceedings of the Elliott Society, Vol. I, page 53 (quoted by Mr. Gee, in his article above mentioned), and by Prof. Ezra Brainerd in the Bulletin of the Charleston Museum, Vol. 3, p. 33, April 1907. Mr. Ravenal could find very little trace of the garden—two clusters of the tallow tree of China, (Stillingia sebifera) and "one or two other things, were the only memorials left of his botanical garden." Prof. Brainard found nothing at all that seemed to have been planted by hand.

I had long felt a "motion of love" to see the spot where Thomas Walter lived and died, and as nothing had been heard of the condition of the place for several years I took an opportunity in August of last year and carried out the long planned trip.

Arriving at St. Stevens from Charleston in the evening I made arrangements with Mr. W. F. Boykin for a conveyance, and made an early start with him the next morning for Pineville, six miles away. The road passed through flat, sandy, pine woods, an occasional low bog, and much good farming land. Close at hand towards the north stretched the broad swamp of the Santee river, five miles wide in places. In the old days before the Revolution when the up country was still an untouched wilderness this swamp was cleared and cultivated in corn and indigo for a distance of at least 10 miles west of St Stevens. Within this swamp at that time were five thousand negro slaves, and on the low bluffs along the southern edge of the swamp there were scattered the comfortable dwellings of the planters. Here wealth and refinement established themselves, and upper St. Stevens and St. John's became the seat of one of the most cultivated and prosperous societies of the state. Now all is changed. The dark days began by the breaking upon the people of the frightful storm of the revolution. No other part of the country suffered more from the ravages of a destructive war. The internecine character of the struggle is well illustrated by the fact that after the battle of Black Mingo Charles and Thomas Peyre, the brothers of the wife of Thomas Walter, were captured as tories by General Francis Marion—a near neighbor—and sent on foot to be jailed in Philadelphia. The sufferings of Marion's men are well known, the misfortunes of the Tories were equally severe.

Impoverished by the war the planter's families found little hope before them. The loss of England's bounty of sixpence a pound on indigo put an end almort immediately to the planting of that crop; and to add to the miseries of the people the Santee river, about 1790, began to be subject to disastrous floods that destroyed the magnificent crops of the rich swamps and drove the planters to give them up once more to the wilderness. They have never again been cleared.

The introduction of cotton as a profitable crop by the invention of the saw gin in 1794 was a most timely and present help in trouble, and saved the country from complete impoverishment. A large number of fine plantations along the south side of the Santee from St. Steven's to Eutawville soon gained a fair measure of prosperity. Until about 1794 the propietors lived on their plantations throughout the year, but after that they got together and established the town of Pineville where they built their summer homes. At the time of its geatest prosperity the village contained about 60 houses, supported a fine academy, and was the center of a community that reflected all that was best of simplicity, hospitality and culture in southern life before the war.

When I passed through the village on that Sunday morning last August no trace was to be seen of the life of the old days. But three or four houses remained—remained only to mark the backward swing of the inconstant pendulum of time.

From Pineville we drove on to the club-house of the Oakland Gun Club, where we ate our lunch and with fresh horses took to the saddle for the remaining distance. After about a mile through the barrens we came to Belle Isle, one of the old plantations of the Marion family. In a fine grove at the end of an avenue stands the old house, with smoke house and kitchen of substantial brick in the rear. It is difficult to imagine a more depressing spectacle than the one that met us here. The house, once the focus of the abounding life and hospitality of a famous estate, is now fast falling into ruin. The steps are gone, the ceiling of the piazza is down at one end, and the roof broken through in several places. As I entered the house and picked my way over the insecure floor to it's dark central passages I was startled by the sudden falling of clouds of bats that squeaked and circled about me.

About one hundred feet west of the house is the old family burying ground. Here are the graves of General Francis Marion and his wife. Over the former the General assembly of South Carolina has erected a substantial memorial of granite with a tablet of bronze (see the accompanying photograph, Pl. XIII). Through correspondence with Mr. John Henry Porcher of Bonneau, who has an extensive knowledge of the history of this section, I learn that, contrary to the impression of many, General Marion never lived at Belle Isle. He was born on his father's plantation, Pond Bluff, near Eutaw Spings (now Eutawville), and lived there most of his life. He did live for a time before the revolution at Burnt Savanna Plantation, which immediately adjoined Belle Isle on the west and is now a part of it.

Moving on to the west from Belle Isle we passed a few fields cultivated by negroes and were soon in the heart of as wild a country as is to be found in the state. Broad stretches of thick pine woods, dense canebrakes and impenetrable bogs surrounded us, and to the north extended for miles the great, deep swamp of the Santee. Here is the paradise of the wild things. Hardly a hundred yards was passed without fresh signs of deer. There are said to be more of these and of bear, turkey and wild cat here than in any other section of the state.

After covering about four miles more we arrived at the old Santee Canal, finished in 1800, at an immense cost, and once filled with boats, lined with fine plantations, and resounding with the songs of negroes—now passing through an almost trackless forest and abandoned to decay. The massive masonry work of the locks of this canal is of brick that is said to have been imported from

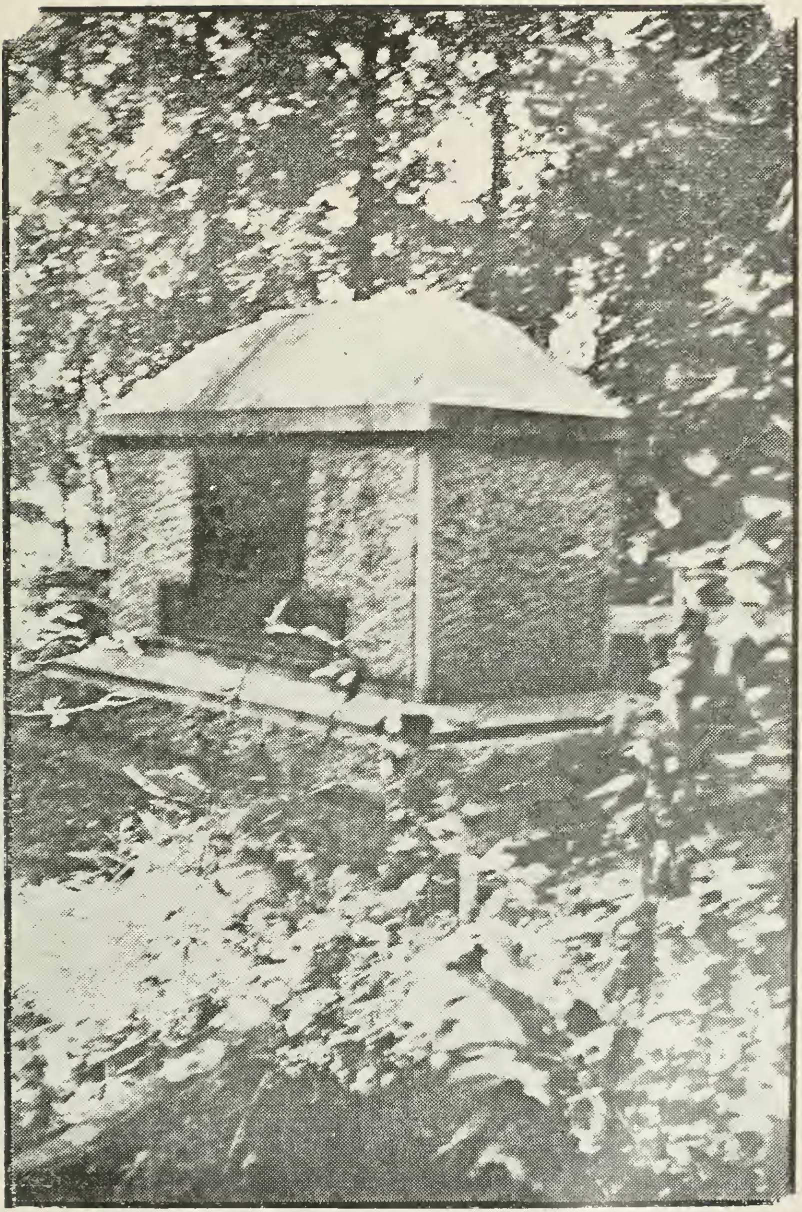

**Plate 13**—Grave of Gen. Frances Marion

England. The remarkable preservation of much of this masonry after the ravages of over a century of neglect is an evidence of the thoroughness and honest workmanship that was characteristic of the times.

On examining one of the most perfect of these locks there was noted on the east wall a thick fringe of the exotic-looking fern, Pteris serrulata, a native of China that is now naturalized in the extreme southern states. This is, I believe, the farthest north that it has been found. The only other fern on the lock was the ebony spleenwort (Asplenium platyneuron). On the west wall was an equally luxurient mass of the very attractive southern vine, Decumaria barbara. This vine is characteristic of the coastal region. It extends up as far as Darlington County, but does not quite reach Hartsville.

The horses were urged through the water and sticky mud of the canal with difficulty and passing on for a short distance we came suddenly to a clearing where the trees had recently been logged. The river current sweeping through the swamp towards the south presses up here to the front of some high bluffs. At this point is standing the base af a massive chimney and parts of heavy machinery are lying around, said to be the remains of one of the old pumping stations of the canal.

Mr. Boykin went off to the south to find an old negro, who finally arrived and led me a half mile farther up the river which had again bent away into the swamp. Here about one hundred feet from the edge of the swamp are standing two fine old willow oaks and at the foot of one of these is the grave of Thomas Walter. It is covered with a flat stone, now broken in two and though dotted with lichens and stained and corroded by time the inscription may still be deciphered. As there are several mistakes in the inscription as published by Ravenel and republished by Sargent and Gee I give it below just as it appears on the stone:*

*The best copy of the inscription is that accompanying Prof. Brainerd's article. In lettering and arrangement it is quite accurate, but I find that it differs in three words from my copy as given above.

In Memory
of
THOMAS WALTER
Native of Hampshire in England
and many years a resident of this
State. He died in the beginning of
the year 1788 aetatis cir. 48 ann.
To a mind liberally endowed
by nature and refined by a liberal
education he added a taste to
the study of Natural History
and in the department of
Botany science is much
indebted to his labors.
At his desire he was buried on
this spot once the garden in
which were cultivated most
of the plants of his
FLORA CAROLINIANA.
From motives of filial affection
his only surviving Children
ANN and MARY
have placed this memorial.

It was hard to believe that on this spot was one of the first Botanical gardens of America, planted and tended with loving care by the man who lay at our feet; that in this deserted place was kindled one of the first fires on the alter of Science in the new world.

I looked about me for those traces of the garden that Ravenel had mentioned more than fifty years ago. Not one remained. No Stellingia or any other thing except the wildest growth of the forest. Leaning over the grave was the southern buckthorn, (Bumelia lycioides), deciduous holly (Ilex decidua), arrow wood (Viburnum dentatum) and red ash (Fraxinus pennsylvanica). From their branches hung Virginia Creeper (Ampelopsis quinquefolia), poison ivy (Rhus radicans), Carolina moonseed (Cebatha Carolina), Cat-brier (Smilax Bona-nox) and Trachelospermum

40

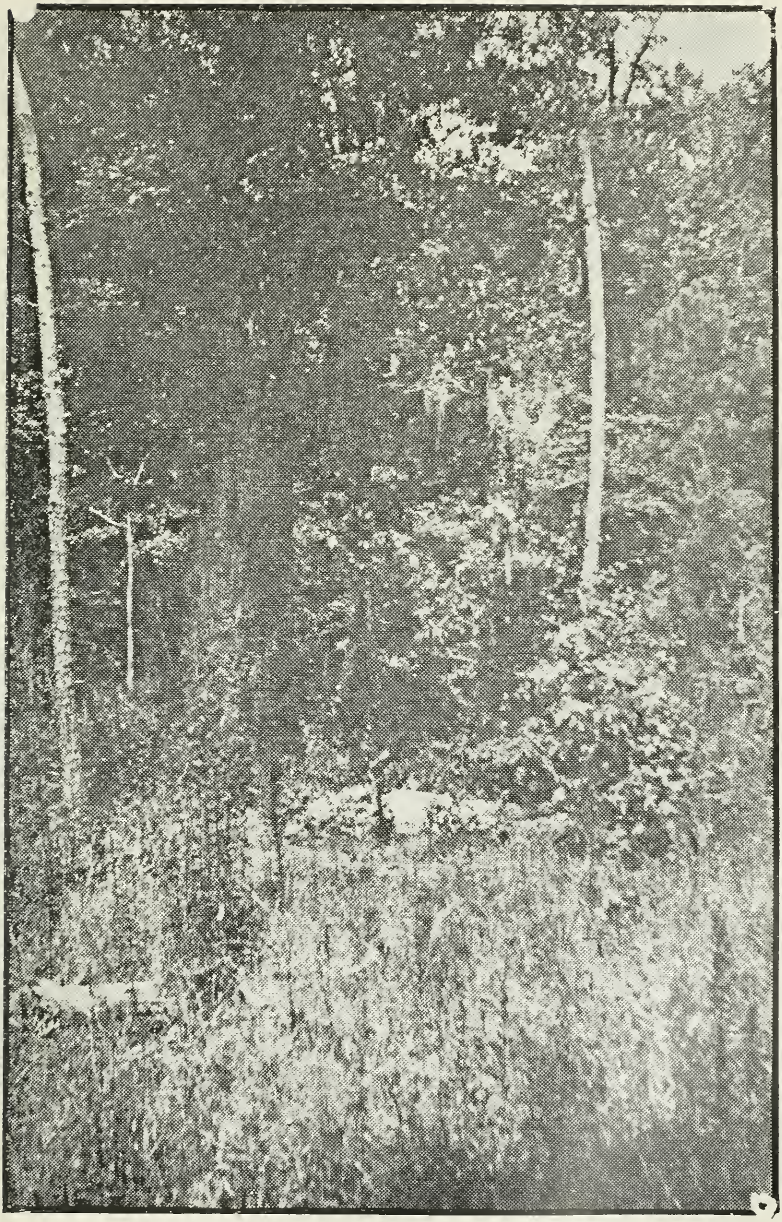

Plate 14—Grave of Thomas Walter

difforme, a vine that was discovered by Walter himself. The only flowers that were immediately about the grave were Salvia lyrata (in fruit), Oxalis colorea and a large false fox-glove (Dasytoma bignoniiflora) that does not seem to have been found in the state before I saw it here. The ancient oak at the head of the stone was heavily draped with the long grey moss (Tillandsia usneoides), as fitting an emblem of graves as cypress or yew.

Two photographs were taken of the stone—one standing close, the other at a distance of about fifty feet. The latter (Plate XIV) shows well the sad desertion of the spot and the complete encroachment of the forest growth.

Ontside the swamp in the immediate neighborhood of the grave were Pinus taeda, Liquidambar styraciflua, Quercus stellata, Rhus copalina, Myrica cerifera, Celtis crassifolia, Ulmus americana, Hicoria aquatica, Ilex opaca and Cornus stricta.

At a distance not greater than a half mile were collected Malus angustifolia, Styrax americana, Amorpha fruticosa, Azelea nudiflora, Vaccinium australe, Vaccinium fuscatum, Vitis aestivalis, Gaylussacia frondosa, Strophostyles umbellata, Penstemon australis, Lespedeza angustifolia, Meibomia obtusa, Arundinaria tecta, Uniola longifolia, Uniola laxa.

On the way from St. Steven's to Walter's grave the following plants were noticed: Pinus australis, Pinus taeda, Pinus echinata, Pinus serotina, Juniperus virginiana, Quercus virginiana (not common here), Quercus aquatica, quercus tinctoria, Quercus falcata, Quercus Catesbaei, Quercus cinnerea, Quercus marilandica, Quercus pumila, Nyassa sylvatica, Castania pumila, Acer carolinianum, Liquidambar styraciflua, Fraxinus pennsylvanica, Ilex opaca, Ilex verticillata, Ilex glabra, Ilex corriacea, Ilex myrtifolia, Ulmus americana, Ulmus alata, Diospyros virginica, Platinus occidentalis, Hicoria tomentosa, Cornus florida, Cornus stricta, Taxodium distichum, Salix nigra, Sassafras sassafras, Magnolia glauca, Myrica cerifera, Cyrilla racemiflora, Alnus rugosa, Cephalanthus occidentalis, Callicarpa americana, Rhus toxicodendron, Viburnum dentatum, Pyrus arbutifolia, Ceanothus americanus Clethra alnifolia, Xolisma foliosiflora, Pieris mariana, Gaylussacia dumosa, Chionanthus virginica, Euonimus americanus, Ascyrum stans, Smilax

Walteri, Smilax glauca, Wistaria frutescens, Eupatorium semiserratum, Eupatorium Mohrii. Seriocarpus bifoliatus, Seriocarpus unifolia, Elephantopus tomentosus, Elephantopus carolinianus, Gnaphalium obtusafolium, Hieracium Gronovii, Conoclinum coelestinum, Laciniaria spicata, Chaenolobus undulatus, Chrysopsis graminifolia, Meibomia Dillenii, Lespedeza repens, Lespedeza japonica, Cracca virginiana, Crotolaria Purshii, Chamaecrista nictitans, Apios apios, Rhexia virginica, Rhexia mariana, Rhexia glauca, Breweria trichosanthes, Agrimonia pumila, Koellia hyssopifolia, Sida Elliotti, Mesophaerum rugosum, Oenothera biennis, Boehmeria scabra, Eryngium integrifolium, Septilia, caroliniana, Lilium Catesbaei, Pontederia cordata, Sarracenia minor, Juncus aristulatus, Habenaria Nuttallii (recently reported by me from South Carolina for the first time), Osmuda cinnamomea, Osmunda spectabilis, Woodwardia areolata, Pteris aquilina, Asplenium platyneuron, Eupatorium rotundifolium.

# VITALITY OF PINE SEEDS AND THE DELAYED OPENING OF CONES*

BY W. C. COKER

On a visit to California in July, 1908, my curiosity was aroused by the remarkable retention of the still unopened cones in *Pinus attenuata* (*P. tuberculata*) the knob-cone pine, and to a somewhat less conspicuous degree in the Monterey pine (*Pinus radiata*). Trees of *Pinus attenuata* may frequently be seen several feet in diameter and thirty or forty years old, still retaining unopened all the cones they have produced during their lives, the lowest cones circling the tree within hand's reach from the ground. As all cones are borne on new growth it is obvious that as the branches increase in thickness the peduncles of the cones must be broken loose from their connection with the wood, so as to allow the cones to be pushed out by the annual growth, or the cones will be covered as the tree develops and finally imbedded in the wood. As the cones of *P. attenuata* are narrow at the base and othus mre easily caught by the annual layers, the latter alternative sometimes occurs and the cones are covered by the growth of the tree.

The cones that remain on the surface of the trunk and branches have no organic connection with the tree, and their peduncles, which are almost an inch long, may be twisted out like a cork from a bottle. It is a well-known fact that in this case the cones never shed their seeds until the tree or branch that bears them dies.

This remarkable peculiarity is exhibited to almost as great a degree by *Pinus radiata* (Monteoey Pine). Of this tree J. G. Lemmon says†:

*Reprinted from The American Naturalist, Vol. 43, Nov. 1909.

†*Sierra Club Bulletin*, Vol. 2, p. 74, 1897.

"Trees four and five inches in diameter may be seen on Point Pinos, still retaining every cone they have produced, circling the trunk and limbs from base to apex. Of course the lumber is perforated with holes, the channels formed by the cone-stems on their many years' journey from heart to bark."

Other species of western American pines whose cones are serotinous to a greater or less degree are *P. muricata*, *P. contorta*, *P. contorta* var. *Murrayana* (the lodge pole pine) and *P. chihuahuana*. Of *P. muricata* Lemmon says*: "The cones have been known to remain unopened for twenty or thirty years, then to release good seeds," but he says in another place of the cones of the same tree†: "They usually open at the time the leaves at the same point fall away from the stems". The *Gardener's Chronicle* for April 24, 1909 gives a good illustration of this pine showing old unopened cones, and in the same number, Mr. J. W. Bean says: "Some of the trees at Kew bear cones which must have developed more than a quarter of a century ago".

Of the eastern American pines the only ones to retain their cones unopened after maturity are the jack pine (*P. Banksiana*) of the north, the Table Mountain pine (*P. pungens*) of the Alleghanies, the pond pine (*P. serotina*) of the southern states, and *P. clausa* of the gulf coast and eastern Florida. In the case of the last species the cones may become imbedded in the wood as in *P. attenuata*‡.

That this remarkable habit of cone retention is of use in the struggle for existence, at least under the peculiar conditions that exist in our western country, is believed by a number of observers. The explanation that is usually offered is well expressed by John Muir in "Our National Parks" page 104. Speaking of *Pinus attenuata* (under the name of *P. tuberculata*) he says:

"This admirable little tree grows on bushy, sun-beaten slopes, which from their position and the inflamable character of the

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**Handbook of West American Cone-bearers*, 3d ed.

†*Erythea*, Vol. 2, p. 160, 1894.

‡In *Garden and Forest*, Vol. 10, p. 232, Professor C. S. Sargeant remarks that cones of *P. muricata* often become imbedded in the bark, but in a letter to me he says that this "appears to be erroneous".

vegetation are most frequently fire-swept. These grounds it is able to hold against all comers, however big and strong, by saving its seeds until death, when all it has produced are scattered over the bare cleared ground, and a new generation quickly springs out of the ashes.''

This statement of Mr. Muir's implies that all or a large part of the seeds produced during the life of the tree are capable of germination when shed, and this seems to be the opinion of others (see Lemmon, as quoted above, under *P. muricata**).

Now it is a well-known fact that pine seeds as a rule are very perishable (seeds of *P. palustris* will not germinate, according to my experience, the second spring after their maturity) and it is important to test by actual experiment to what extent seeds retain their vitality under such conditions. In looking over the literature I can find but one experiment that has been made to enlighten us on this point.

In 1874 Dr. Engleman collected a branch of *Piuns contorta* from Colorado (the plant being probably var. *Murrayana*, or lodge pole pine) and arter keeping it four and a half years, he sent it to Proressor C. S. Sargent, of the Harvard Arboretum, to test the seeds. Professor Sargent planted the seeds in 1879, and his results, as reported in *Bot. Gazette*, Vol. 5, p, 54, 1880, were as follows:

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*The reference to *Pinus radiata* by Vernon Bailey on page 34 of C. Hart Merriam's ''Results of a Biological Survey of Mount Shasta, California'' (*North American Fauna*, 16, 1899) would indicate that its seeds have a hard time on Mount Shasta. He says:

''The trees were loaded with cones, in whorls of three to seven around the branches and down the trunks to 10 or 12 feet from the ground. Some of the cones must have been 20 or 30 years old, and perhaps much older. I cut off a lot of the old lower cones to see if the seed were good, and put them on a boulder and cracked them with a few hard blows of the ax. All of them were full of worm dust, with only now and then an undiscoved seed or a fat white worm. Cones of medium age (5 or 6 years back from the end of the branch) were invariably occupied by worms and worm dust, and usually contained few good seeds. Cones only 1 or 2 years old were rarely wormy. A great many of the old cones had been dug into by woodpeckers, either for seeds or, more likely, for the fat white grubs that live on the seeds.''

Seeds of 1865 and 1868 did not germinate.
1869......24 seeds planted, 4 germinated.
1870......25 seeds planted, 4 germinated.
1871...... 6 seeds planted, 2 germinated.
1872......19 seeds planted, 5 germinated.
1873...... 9 seeds planted, none germinated (cones probably not mature.)

This experiment shows that at least some of the seeds of *P. Contorta* (var. *Murrayana?*) are capable of germination after retention in the cones for nine or ten years.

My interest having been aroused in this subject while in California, I was led to observe more closely the cones of our native *P. serotina* on my return to South Carolina and it was soon found that the cones of this species often remain attached and unopen for a much longer time than ever reported. In his "North American Silva," Vol. 3, p. 117, Michaux says: "The cones arrive at maturity the second year, but do not release their seeds before the third or fourth."

Sargent follows this statement in his "Silva" and Britton says (in "North American Trees") that the cones "remain closed for several years before dropping the seed." In the neighborhood of Hartsville, South Carolina, it was not at all uncommon to find cones that had remained unopened for ten or even more years, and the opportunity was taken to collect cones of different ages for a test of the vitality of the seeds. The cones were taken to the New York Botanical Garden and there the test was made in June of this year. Seeds that were obviously blasted or dead (as shown by floating in water) were discarded, and are recorded as "rejected"; only apparently sound seed were planted. The seeds were first germinated between filter paper in *Sphagnum* moss for about five days until the radicals appeared. A count was then made and the results recorded in the columns of June 29 in the table below.‡ All the seeds, whether germinated or not, were then planted in soil in pots, and the seedlings that appeared were coun-

‡Cone No. 1 was not included in this count because its seeds were by mistake planted in soil before the count was taken.

ted on July 12† and July 22, with results as shown in the table below.

| Years Old. | Rejected. | Planted. | June 29. | July 12. | July 22. |
|---|---|---|---|---|---|
| 3 | 31 | 32 | ? | 27 | 28 |
| 4 | 10 | 14 | 6 | 9 | 9 |
| 4 | 6 | 15 | 13 | 9 | 9 |
| 6 | 7 | 57 | 30 | 40 | 39 |
| 6 | 0 | 62 | 52 | 51 | 52 |
| 6 | 7 | 60 | 58 | 53 | 48 |
| 7 | 3 | 88 | 42 | 50 | 44 |
| 8 | 7 | 49 | 10 | 34 | 33 |
| 8 | 5 | 27 | 2 | 15 | 18 |
| 8 | 3 | 42 | 0 | 31 | 33 |
| 9 | 5 | 34 | 3 | 2 | 0 |
| 9 | 2 | 31 | 10 | 16 | 7 |
| 14 | 32 | 61 | 33 | 24 | 21 |
| 14 | 2 | 67 | 7 | 11 | 11 |

Increasing numbers in the later readings are due to delayed germinations: decreased numbers to failure to emerge or to damping off after emergence.

It should be noted that the conditions that exist in these serotinous cones are almost ideal for the preservation of the vitality of the seeds. While some exchange of gases is allowed, the spores of fungi and bacteria are effectually excluded; and most important of all, a sufficient humidity is maintained to prevent a fatal dehiscence. That this humidity is due to contact with the moist wood of the live trees is shown by the mechanical opening of the cone through drying when it is removed from the wood, or when the tree dies. This opening, however, is not always either prompt or complete.

Chapel Hill, N. C.

†This counting was, in my absence, kindly made by Mr. Fred. J. Seaver.

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## Proceedings of the North Carolina Academy of Science.

The North Carolina Academy of Science held its ninth annual meeting at Wake Forest College, Wake Forest, N. C., on Friday and Saturday, April 29 and 30, 1910.

The Executive Committee met at 3:50 P. M., there being present President W. C. Coker and Secretary E. W. Gudger, *ex officio,* and C. W. Edwards. The Secretary-Treasurer made his report, which was favorably recommended to the Academy in the following items.

The following applicants for membership in the Academy were elected: T. W. Addicks, Assistant Curator State Museum, Raleigh; W. M. Allen, State Food Chemist, Raleigh; Bronson Barlow, State Botanist, Raleigh; Julian Blanchard, Professor of Engineering, Trinity College, Durham; Donald Boyer, Instructor in Sciences, High School, Kinston; S. C. Bruner, student A. & M. College, West Raleigh; R. W. Collett, Supt. State Experimental Farms, Swannanoa; Eva L. Culbreth, Assistant in Mathematics, State Normal College, Greensboro; P. W. Daggett, Associate Professor of Physics, University of N. C., Chapel Hill; L. A. Denson, Section Director Weather Bureau, Raleigh; John W. Ferrell, Assistant Secretary for Hookworm, State Board of Health, Raleigh; R. L. Flowers, Professor of Mathematics, Trinity College, Durham; W. H. Fry, Instructor in Geology, University of N. C., Chapel Hill; P. L. Gainey, Assistant Bacteriologist, A. & M. College, West Raleigh; Anna M. Gove, Physician to State Normal College, Greensboro; W. C. A. Hammel, Professor of Physics, State Normal College, Greensboro; B. B. Higgins, West Raleigh; Hampden Hill, Instructor in Chemistry, University of N. C., Chapel Hill; J. C.

Hines, Jr., Instructor in Mathematics, University of N. C., Chapel Hill; J. S. Holmes, Forester State Geological and Economic Survey, Chapel Hill; A. Wilson Hobbs, Assistant in Mathematics, Guilford College; Mrs. W. N. Hutt, Chairman Woman's Branch Farmers' Institutes of N. C., Raleigh; J. D. Ives, Assistant in Biology, Wake Forest College; C. A. Julian, Assistant Secretary for Tuberculosis, State Board of Health, Thomasville; Rev. Geo. Wm. Lay, Rector St. Mary's School, Raleigh; I. F. Lewis, Professor of Biology, Randolph-Macon College, Ashland, Va.; L. B. Lockhart, State Oil Chemist, Raleigh; Alma J. Long, Professor of Domestic Art, State Normal College, Greensboro; Jno. W. MacConnell, Professor of Biology, Davidson College; C. B. Markham, Assistant Professor of Mathematics, Trinity College, Durham; Gertrude W. Mendenhall, Professor of Mathematics, State Normal College, Greensboro; Mrs. Z. P. Metcalf, Raleigh; C. L. Newman, Professor of Agriculture, A. & M. College, West Raleigh; Nettie L. Parker, Assistant in Mathematics, State Normal College, Greensboro; A. H. Patterson, Professor of Physics, University of N. C., Chapel Hill; Mary M. Petty, Professor of Chemistry, State Normal College, Greensboro; John B. Powers, Professor of Bacteriology and Pathology, Wake Forest College; Mary Robinson, Assistant in Biology, State Normal College, Greensboro; F. W. Sherwood, Assistant Chemist, N. C. Agricultural Experiment Sta., West Raleigh; C. A. Sprague, Instructor in Physics, A. & M. College, West Raleigh; C. W. Stiles, Scientific Secretary Rockefeller Sanitary Commission, Washington, D. C.; Cora L. Strong, Associate Professor of Mathematics, State Normal College, Greensboro; Opal I. Tillman, Scientific Assistant, Bureau Plant Industry, Washington, D. C.; L. F. Williams, Assistant Professor of Chemistry, A. & M. College, West Raleigh; E. L. Worthen, State Soil Expert, Raleigh; E. P. Wood, Assistant State Veterinarian, Raleigh.

The following amendments to the Constitution proposed by the Secretary, were endorsed for favorable action by the Academy. In Art. II., Sec. 1, as amended May 1, 1910, strike out the words "dues for the current year" and insert "initiation fee." In Art. II., Sec. 2, before the words "The annual dues" insert this sentence, "The initiation fee shall be two dollars, payable in advance, and there shall be no annual dues for the first year."

The Committee requested the Secretary to explain to the Academy that his action in deferring the printing of the Constitution and list of members until autumn, 1910, in order to include the new amendments and the enlarged list of members, had been authorized by it in March, 1910.

It was moved and carried that hereafter, in order to give time for discussion, all papers be limited to 15 minutes unless longer time has been allotted by previous permission of the Executive Committee; that as far as possible, papers be placed on the program as their authors wish, provided, however, that all members have an opportunity to present one paper before any member gives a second; that a paper not read when called for shall go to the foot of the list.

At 4:15 P. M. the Academy was called to order, President W. C. Coker in the chair. The following committees were appointed: To audit Treasurer's accounts, W. A. Withers, Franklin Sherman, Jr., J. J. Wolfe; to nominate officers for the ensuing year, W. L. Poteat, G. W. Lay, Collier Cobb; on resolutions, J. G. Hall, Franklin Sherman, Jr., Z. P. Metcalf.

The balance of the afternoon was spent in reading and discussing papers.

At 8:30 P. M. the Academy reassembled in Wingate Memorial Hall, and was cordially welcomed to Wake Forest College by President W. L. Poteat. President W. C. Coker, of the Academy, fittingly responded and then gave the presidential address, "Science Teaching in the Schools and Colleges of North Carolina."

Because of their general interest, the following papers were presented at this evening meeting, which was largely attended by the college people: "Pellagra: A Preliminary Report," by J. J. Wolfe (with lantern slides); "Halley's Comet," by A. H. Patterson (illustrated with lantern slides); "The Comet: What Is It?" by John F. Lanneau (illustrated by chart).

At 8:45 A. M. Saturday, the Academy reassembled for the annual business meeting. The minutes of last meeting were read and approved. The recommendations of the Executive Committee, as itemized above, were unanimously endorsed. The names of the new members were read. The amendments as proposed were carried. The recommendations about papers on program were agreed to without dissent. On motion, the Secretary was authorized to print the revised Constitution and mail a copy to each member, securing a sufficient number of extra copies to supply future demands.

The Auditing Committee reported that the Treasurer's accounts were found to be correct, there being an available balance of $167.29 less $50.00 due for publishing the proceedings for 1909.

The Nominating Committee brought in the following nominations: President, W. H. Pegram, Professor of Chemistry, Trinity College, Durham; Vice-President, W. S. Rankin, Secretary State Board of Health, Raleigh; Secretary-Treasurer, E. W. Gudger, Professor of Biology, State Normal College, Greensboro;

Executive Committee: F. L. Stevens, Professor of Biology, A. & M. College, West Raleigh; H. H. Brimley, Curator State Museum, Raleigh; H. V. Wilson, Professor of Zoölogy, University of N. C., Chapel Hill.

In the absence of the Chairman, Prof. C. W. Edwards, President Coker reported progress for the Committee on Science Teaching in North Carolina High Schools and Colleges, saying that they had found it impossible to collect and digest the data in time to report at this meeting.

On motion the following committee was appointed to collect data and plan courses of study in the sciences for the high schools of the State, to be submitted for approval by the Academy at the next annual meeting: W. C. Coker, University of North Carolina; C. W. Edwards, Trinity College; G. W. Lay, St. Mary's School; Donald Boyer, Kinston High School; H. V. Wilson, University of North Carolina; F. L. Stevens, A. & M. College; Collier Cobb, University of North Carolina; J. E.

Mills, University of North Carolina; E. W. Gudger, State Normal College.

The business meeting being over, the reading of papers was resumed, and with a short interruption for lunch was concluded at 3:00 P. M. The Committee on Resolutions brought in the following report:

*Resolved,* That we, the North Carolina Academy of Science, hereby extend our sincere thanks to Wake Forest College for kindness in supplying for us a place of meeting, and for other favors, and

*Resolved,* That we wish to express our especial appreciation of the kindness of the members of the faculty and their families and others who have so courteously entertained us, and

*Resolved,* That we wish to express our gratification for the activity of our Secretary-Treasurer in the zealous discharge of his duties.

The following members were in attendance: T. W. Addicks, W. M. Allen, B. Barlow, J. Blanchard, J. G. Boomhour, W. G. Chrisman, S. C. Clapp, Collier Cobb, W. C. Coker, C. W. Edwards, P. L. Gainey, E. W. Gudger, J. G. Hall, B. B. Higgins, W. N. Hutt, J. D. Ives, J. F. Lanneau, G. W. Lay, C. B. Markham, Mrs. Z. P. Metcalf, A. H. Patterson, W. L. Poteat, J. B. Powers, F. Sherman, Jr., F. W. Sherwood, R. I. Smith, F. L. Stevens, Opal I. Tillman, W. A. Withers, J. J. Wolfe.

This meeting equalled any other in number of papers, and excelled any in attendance, in discussion of papers, and in general interest. The number of new members received is 46, of old members enrolled, 43; total, 89.

Adjourned, 3 P. M.

The following papers were presented:

*The Cause of Pellagra—A Preliminary Report,* Jas. J. Wolfe, Trinity College, Durham.

Believing that Pellagra must be an infectious disease, and that, because of its generalized nature, the organism was most likely to occur in the blood, the writer last September began a study of some specimens of pellagrous blood, with the hope of throwing some light on the etiology of this disease.

The usual smear preparation was made, stained with methelene blue and studied under a Zeiss apochromat. Bacteria were seen in considerable numbers in most cases (especially severe ones)—milder cases were more difficult and not as yet entirely convincing. These are polymorphic, but generally spherical; grouped often in doubles like a dumb-bell, or irregular clumps; sometimes in chains, and usually between ½ and 1 micron in diameter.

A culture derived from damaged corn shows an organism quite similar in grouping, size, color, reactions and polymorism. This is now being tested with animals.

*Peculiarities in the Distribution of Some North Carolina Birds,* Franklin Sherman, Jr., State Entomologist, Raleigh.

[This paper appears in full in the current number of this journal.]

*The Comet: What is It?* John F. Lanneau, Wake Forest College.

*The Resin of Pinus Sabiniana,* Charles H. Herty and E. S. Tillett, University of North Carolina, Chapel Hill.

[Read by title.]

*Medical Entomology,* Z. P. Metcalf, Department of Agriculture, Raleigh.

A short popular account of some of the more recent developments in the science of Medical Entomology, which was defined as that branch of Entomology which treats of the relation of insects and insect-like animals in the transfer of diseases from man to man, man to animal, and animal to animal.

This relation was declared to be twofold. In the first case the insect is a necessary intermediate host, and in the second case the insect is merely an incidental or accidental factor in the transfer of the disease. The work of the Board of Health of the city of Asheville was cited as an example of applied Medical Entomology.

*The Ammoniafying of North Carolina Soils,* F. L. Stevens and W. A. Withers, assisted by P. L. Gainey and F. W. Sherwood, N. C. Agricultural Experiment Station, West Raleigh.

*Remarks on the Relation of Our Birds to The Farm and Garden,* C. S. Brimley, Raleigh. Read by F. Sherman, Jr.

[Published in full in the current number of this journal.]

*Where to Find Amebas,* E. W. Gudger, State Normal College, Greensboro.

The directions given in the books are very indefinite, as the writer found to his sorrow in his early biological days. Acting on a suggestion made by Dr. D. H. Tennent, now of Bryn Mawr College, he at that time successfully sought them in the yellowish-green diatom deposits on the bottom of stagnant ditches or of quiet pools in brooks. In seven years these have never failed to furnish abundant material. The writer's classes are supplied from a tiled drain at the foot of a bank less than 100 yards from the laboratory. These amebas vary in size from quite small to those so large that they cannot be seen in their entirety under the ordinary high objective.

*The Origin of Thermal Waters, with Special Reference to Hot Springs, Ark.,* Collier Cobb, University of N. C., Chapel Hill.

*Some Aids to Better Work in Science,* C. W. Edwards, Trinity College, Durham.

[Read by title.]

*A New Hybrid Habenaria of North Carolina,* J. G. Hall, N. C. Agricultural Experiment Station, West Raleigh.

A hybrid Habenaria was reported from the neighborhood of Kinston, N. C. This natural hybrid seemed to be pretty well intermediate between the two supposed parents, H. ciliaris and H. blephariglottis. Photographs of the flowers were shown and these presented some characters of the parents and the hybrid.

*The Present Status of the Darwinian Hypothesis,* W. L. Poteat, Wake Forest College.

*Some Experiments on Ionization by Impact: The Time Variation of the Current through a Gas Ionized by Radium*, J. Blanchard, Trinity College, Durham.

The ionization vessel was a glass tube with parallel plate electrodes about 5 centimeters in diameter, both plates coated (though unequally) with a thin layer of a very impure salt of radium. With the plates about 1 centimeter apart and the pressure about 1 millimeter, with a potential difference sufficient to produce considerable ionization by impact, it was found that the current decreased with the time the battery key remained closed, reaching its minimum value in about an hour. On opening the key the initial conductivity was almost totally regained in about the same time. Upon reversing the potential at the end of an hour the current was sometimes found to be greater than it was initially in this reverse direction, but also decreasing with the time as before.

The potential difference apparently causes an increased amount of ionization near the positive plate, the effect being detected only when the potential gradient is sufficient to cause ionization by impact. Further experiments are in progress.

*Is the Fusarium Which Causes Cowpea Wilt Genetically Connected with Neocosmospora?* B. B. Higgins, N. C. Agricultural Experiment Station, West Raleigh.

In 1889 the wilt disease of cotton was studied by Prof. Geo. F. Atkinson, and its causal fungus named *Fusarium vasinfectum*. A few years later (1894-99) the wilt disease of cotton, watermelon, and cowpea was studied by Erwin F. Smith. He found no specific differences between the fungi upon any of the three hosts. He found, however, upon some of the plants previously killed by the wilt fungus an acigerous fungus which he considered the perfect stage of *Fusarium vasinfectum*. The fungus was therefore renamed by him *Neocosmospora vasinfecta*, and this conclusion has been accepted by subsequent writers. The evidence upon which this conclusion was based was very weak, however; and a recent study of the two forms by the writer—the results of which will at an early date be published in bulletin form—has caused the writer to reopen this question, which was considered closed.

*Some Experiments in the Propagation of the Diamond-Back Terrapin,* Henry D. Aller, Director Laboratory of Fisheries, Beaufort.

Read by the Secretary.

[This paper appears in full in the current number of this journal.]

*The Present Status of the Relativity Problem,* C. W. Edwards, Trinity College, Durham.

[Read by title.]

*The Locus of a Moving Point When the Sum of Its Distances From Two Fixed Points, Their Difference, Their Product, or Their Quotient, is Constant,* John F. Lanneau, Wake Forest College.

The loci determined by the first three conditions are the well known Ellipse, Hyperbola, and Lemniscate.

Under the fourth condition: Take line through the fixed points F and F' as x-axis; the point O, midway between them, as origin; 2c for distance F to F'; K for the constant quotient when the moving point is on one side of the y-axis, and therefore $\frac{1}{k}$ the quotient when it has the corresponding position on the other side.

1. The equation of the locus is $x^2 + y^2 \mp 2c\,\frac{k^2+1}{k^2-1}\,x + c^2 = 0$

The locus, therefore, consists of two equal circles whose centers are on the x-axis beyond F and F' at equal distances from O.

2. A discussion of the equation shows:

If k=1, the circles are of infinite radius, and are tangent at O;
If k is either O or OO, the circles reduce to the points F and F';
If k has, in turn, any series of values between 1 and O, or between 1 and OO, the loci form a group of circles about F and a similar group about F'—the number of circles in each group limited only by the number of values given to k.

3. None of the circles of the F and F' groups pass through either of the fixed points F and F'.

Any circles drawn through F and F' are extraneous to the loci, but each such circle is orthogonal to every circle in the loci groups.

*Notes on Fungi,* F. L. Stevens and J. G. Hall, N. C. Agricultural Experiment Station, West Raleigh.

Three new species of Claviceps were described. Two of them are upon Paspalum and are thought to be the perfect stages of the fungus usually known as *Schlerotium Paspali S.* Germination of the sclerotium was described and the characters of the fungus were illustrated by photographs and specimens. The third species grows upon Gama grass (*Tripsacum dactyloides L.*) Both sphacelia and ascosporic stages were exhibited. Technical descriptions were given under the names *Claviceps Paspali* (S.) n. comb.; *C. Rolfsii* n. sp.; and *C. Tripsaci* n. sp. These will be published in full elsewhere, soon.

Specimens of a Cercospora upon persimmon, which was thought to be new, were also shown.

*Some Methods of Making Illustrations,* Z. P. Metcalf, Department of Agriculture, Raleigh.

A brief consideration of the more important methods of making illustrations. Drawings with their reproductions were shown covering the following methods: pen and ink, pencil and crayon, watercolor, oil color, photographs, lantern slides and color photography.

*Precautions Necessary in Estimating Climates of Geological Time,* Collier Cobb, University of N. C., Chapel Hill.

*The Jaws of the Spotted Sting Ray, Aetobatus Narinari,* E. W. Gudger, State Normal College, Greensboro.

This ray was discovered in Brazilian waters, described and figured by George Marcgrave sometime between the years 1637 and 1644. His description of fish and jaws was published in 1648. This pavement-toothed ray has but one set of teeth—

the central one—in each jaw, the lateral teeth found in the others of its kind having all disappeared. In the upper jaw are found 14 I-shaped teeth, in the lower 17 broad V-shaped grinders as noted by Marcgrave. The lower jaw is the longer and projects beyond the lips. With it and the fairly long snout, the ray digs up the clams on which it feeds.

The paper was illustrated by photographs of dorsal, ventral, and lateral views of the ray, and by a pair of dried jaws.

The writer has in preparation for the U. S. Bureau of Fisheries a paper in which he hopes to bring together all the work ever done on this fish, and in which will be included his observations and the photographs above mentioned.

*The Cocoanut Crab,* John F. Lanneau, Wake Forest College.

Called also the Robber Crab and the Pouch Crab. Shaped more like a lobster than a crab. Found on islands of the South Pacific. Weight usually 5 or 6 pounds, sometimes 20.

Feeds on fallen cocoanuts. Said to climb the trees. Is highly esteemed as food, especially the rich fatty content of the pouch.

Is found on our island of Guam. It and other singular forms of life on that pleasant little island would repay a biologist's investigation. His visit would likely be facilitated by our Secretary of War or Secretary of Navy.

*A Double Flowering Dogwood,* F. L. Stevens and J. G. Hall, N. C. Agricultural Experiment Station, West Raleigh.

A case of "double-flower" of the common Flowering Dogwood (*Cornus florida L.*) due to the excessive development of the small bracts that subtend the individual flowers of the ordinary head, was reported. There was, as well, the suppression of all the individual flowers except the central one, which appeared entirely normal.

*A Note on the Development of the Gall-Fly Diastrophus Nebulosus, O. S.,* J. D. Ives, Wake Forest College.

[This paper is published in full in this issue.]

*Pecan Culture in North Carolina,* W. N. Hutt, State Horticulturist, Raleigh.

E. W. GUDGER, *Secretary.*

# SUMMARY OF RECENT EXPERIMENTS ON THE CULTURE OF THE DIAMOND-BACK TERRAPIN AT THE FISHERIES LABORATORY, BEAUFORT, N. C.

By Henry D. Aller,
Director Beaufort Laboratory.

It having been determined by the Bureau of Fisheries to resume experimental work looking toward the culture of the diamond-back terrapin at the Beaufort, N. C., laboratory, the construction of a large concrete pound was begun at that place late in the year of 1908. The concrete work consisted of one side wall, 45½ feet long, running parallel to the shore, and two end walls, each 28½ feet long, running at right angles to the other wall. Plank extensions inshore gave a rectangular pound 45½ feet by 44½ feet. The location of the pound was such that during a portion of each tide a part of the interior was flooded with salt water. An opening about three feet wide in the offshore wall, crossed by gratings to prevent the escape of terrapins, permitted the tide to rise and fall freely within the pound. With ordinary tides a considerable part of the interior of the pound was above high water level.

The stock of terrapins consisted of about a dozen which had been kept at the laboratory for a number of years, being a part of those used for experimental work at Beaufort, twenty purchased from a firm at Crisfield, Md., and a number secured from local sources. In all between sixty and seventy were available for the work, in the proportion of about two females to one male. They were placed in the pound in the spring or early in the summer of 1909. They were fed abundantly, mostly on crabs and fresh fish. During the season there was no evidence of any egg-laying. During December, 1909, while excavating a quantity of earth from the pound, a number of young diamond-backs were unexpectedly discovered. Twelve in all were found. Eleven were in good condition, the twelfth having been injured in the excavation work. They were of uniform size, measuring from 25 to 28 millimeters in length, the lengths being taken along the median line of the plastron. The young were buried in sand in various places, some in the laboratory and others out of doors. No special care was given them, aside from keeping the sand containing those in the laboratory moist and in protecting all from freezing. No food was given them. They remained buried until about the first or second week in April, when they began to come to the surface, as if preparing for an active existence.

The chief conclusions are: first, that diamond-back terrapins will breed in captivity with little attention, provided they have plenty of food and free access to water; second, the young may be easily cared for during the early part of their life. Apparently all the young were hatched from eggs laid in ground which had received no attention. So far as is known, none were hatched in the sand-beds prepared for nests. It is not necessary, and perhaps not possible to supply the young with food prior to the spring following the year during which they were hatched.

During June, 1909, a number of eggs were collected from nests made under natural conditions in the vicinity of Beaufort. These eggs were buried in sand at the laboratory, but the attempt to hatch them was not successful. Whether the failure was due to improper handling of the eggs cannot be said, but it is doubtful whether this method of raising terrapins would ever be of any economic value.

The work has been carried on under the general direction of Prof. W. P. Hay, of Washington, D. C.

# REMARKS ON THE RELATION OF BIRDS TO OUR FARMS AND GARDENS.

By C. S. Brimley.

This paper is prompted by a letter that appeared some time ago in the Progressive Farmer, in which the writer stated that he wished there were one thousand beneficial birds to every one we now have, and in which he advocated the stopping of all hunting and shooting as a means to secure that desired end, evidently thinking that if birds were only let alone they would increase indefinitely, which of course is not the case. This leads me to ask the question,—Why are not birds more numerous in our farms and gardens, and why do they not eat up more of the insect pests that destroy our crops? A good many persons would answer that there were not enough of them, and would say that the scarcity was caused by the recent wholesale destruction of them for millinery purposes, being unaware that practically all the birds killed for that purpose of late years have been shore and sea birds which would only occur on cultivated land under exceptional circumstances.

Now there is undoubtedly rather a scarcity of birds on the average southern farm, and what we want to do is to find out the reason for it, and see if a change cannot be brought about.

If then we consider the natural habits of our small land birds, what do we find? Just this, that a very large majority of them are naturally woodland birds, and what may I ask is there in acre after acre of such clean culture crops as corn, cotton or tobacco, to attract any forest loving species at all? Frequently too we find the farm house standing unshaded with no trees around it, often there is no orchard, and the only birds that will frequent such a farm are those that can find patches of briars or bushes to build their nests in. Mind you I am not saying there may not be plenty of birds in the adjacent woods, but they would feed and breed in the woods, and would hardly be seen on the farm at all.

What is the remedy for this? Let the farmer plant some shade trees, and an orchard, and when the trees get big enough he will find birds will come and nest in them, and vice versa, if he cuts his trees down the birds will leave also. I can give an actual instance of the latter fact. There used to be a little way from Raleigh, a large mulberry orchard, in which orioles, tanagers, yellow warblers, catbirds, cardinals, kingbirds and others dwelt in numbers during the summers, in fact there were more individual birds there than in almost any place I ever saw. Now, however, that orchard has been entirely cut down, and with the disappearance of the trees the birds have also disappeared.

Then again if he has a real pasture, not merely a fenced-in piece of swamp or pine woods, he will find a few kinds will sooner or later be attracted to it and will nest there. Mind you I am not saying that we can get enough birds on any farm to be a substitute for paris green or arsenate of lead as a remedy against injurious insects; in fact I am inclined to look upon that as an iridescent dream, but still by paying some attention to the needs of the birds we can get quite a number of kinds to make their homes near our homes, and that without doing anything that we ought not to do anyhow.

To take a concrete instance, I moved to my present residence, some ten years ago, and at that time there were a lot of big trees around the house, but nothing else. Since then, however, I have planted a lot of bushes,and some fruit trees, so that there is a great deal more growth on the lot than there was when I came there, and there are also a good many more birds there both winter and summer than at first.

Now, what are the birds that will be attracted by such measures to the neighborhood of our dwellings, and of course the answer is only those that are able to adapt themselves to the changed conditions brought about by man. The species that will come around in *summer* under such conditions are the robin, the bluebird (if there is a suitable hole or two for him to nest in), the purple martin (if we hang up martin gourds), the summer tanager, yellow warbler, red-eyed and yellow-throated vireos, crested flycatcher—also dependent on a nice hole for a nesting site, wood pewee, catbird, mockingbird, carolina wren, (he is likely to come anyway) red-headed woodpecker (if there are oaks to furnish him acorns) field sparrow, chipping sparrow, English sparrow and others that I do not call to mind at present.

Sad to say, however, most of these birds, all of which, except the martin, nest more or less on my lot, stay up in their trees, and do not come into my garden at all, the exceptions being the three kinds of sparrows mentioned, the catbird, carolina wren, with an occasional summer tanager and wood pewee. The two vireos never come there. This brings me to another phase of the subject, which is that do what we will, we are not going to get birds that are naturally arboreal to come down out of their trees and feed on the ground, however much we may want them to do so—and hence I believe that our birds must inevitably be of much greater importance to the forester than to the farmer. Some of the species mentioned above, however, may be economically useful, and these are the two native sparrows and the catbird.

Passing now to our *winter* birds, we find these largely frequent clumps of bushes and thickets, while other species are found in open fields, and many of these latter undoubtedly are beneficial on account of the cutworms, white grubs, and other insects they destroy, the meadowlark and titlark being familiar examples of such open field birds. Those species that inhabit thickets, both great and small, undoubtedly also destroy large numbers of hibernating insects that would otherwise come out next spring to do damage, and which pass the winter in the shelter of such places. In fact, offhand it looks as if the winter birds might do more good than the summer species.

The principal winter birds that frequent thickets or clumps of bushes in and around fields are the song, white-throated, and field sparrows and the slate-colored junco (snowbird), all of which, especially the first two, are common in my garden.

# DEVELOPMENT OF SPONGES FROM TISSUE CELLS OUTSIDE THE BODY OF THE PARENT*.

By H. V. Wilson.

About five years ago I suggested to the Bureau of Fisheries that an investigation to cover the various ways in which sponges reproduce might yield some results of value for scientific sponge culture. I had in mind the high degree of reproductive (technically, regenerative) power possessed by at least certain body cells, as distinguished from germ cells, in sponges.

This great regenerative power of somatic cells in sponges is displayed, as has long been known, in the formation of asexual masses which under proper conditions develop into new sponges. The regenerative masses of this kind that are best known are the gemmules of fresh-water sponges, but similar gemmules have been discovered by Topsent and others in marine sponges. Observations of my own, dating as far back as 1889,† indicated that in some marine sponges such asexual masses not only possess the power to transform into sponges, but in so doing pass through a swimming stage not distinguishable from the ciliated larva which typically develops from an egg. In a case of this kind, as I have pointed out (op. cit., 1891), the nature of the body cell as measured by its potentialities is fundamentally like that of a germ cell—it has full regenerative power, including the ability to recapitulate in some measure the ancestral history of the protoplasm. Considerations of this kind led me to doubt whether in all metazoa the protoplasm really did divide sharply into somatic and germinal cells. Rather was the idea encouraged that in the lower metazoa, such as sponges, the cellular elements all retained just so much of the nature of the germ cell (just so much of the specific idioplasm, one might say) as would enable them, under the influence of an appropriate stimu-

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*Reprinted from Bulletin of the Bureau of Fisheries, Vol. xxviii, p. 1265-1271, May 1910.

†Wilson, H. V.: Notes on the development of some sponges, Journal of Morphology, 1891; Observations on the gemmule and egg development of marine sponges, ibid., 1894.

lus, to develop either into ova or sperms, or into asexual reproductive masses. Assuming that sponge protoplasm had this eminently plastic character, I conceived that one might discover ways in which to call into unusual activity the reproductive or regenerative power, and so, as it were, to invent new methods of growing sponges.

The results, at this time, of the investigation that I have been conducting for the Bureau during the past five summers at the Beaufort laboratory justify, it seems to me, the point of view above outlined. Two new methods by which sponges may be grown have been discovered, and both of these methods attest the remarkable regenerative power of the body cells of sponges. That both methods are applicable to the commercial sponge there can hardly be a doubt. Whether at the present time any economic advantage would accrue from the practice of either is perhaps doubtful, in view of the fact that sponges may so successfully be grown from cuttings—a method first practiced by Oscar Schmidt, and further developed in this country by Richard Rathbun, while in recent years H. F. Moore has brought it through a long series of admirable experiments to a high degree of efficiency.

But while the methods which I shall presently describe may not now be of practical utility, they add something to our knowledge of the underlying scientific principles of sponge culture. And it is a truism that such principles are the funds, so to speak, on which the practice of succeeding generations draws in the conduct of economic enterprises. I am convinced that our knowledge of these scientific principles of sponge culture may be vastly increased. Future researches will surely clear up, among other points, the relation between the formation of sexual products (ova and sperms), of asexual masses which transform directly without passing through the swimming stage (ciliated larva), and of asexual masses which imitate the egg development in passing through the stage of the ciliated larva. I may add that such a relation is "cleared up" to the eye of science (in contradistinction to metaphysics) only after the discovery of the actual treatment to which, when the sponge tissue is subjected, it responds by the development of this or that reproductive body. In this instance, as in many such biological problems, the most intimate knowledge of the structure and movements of the cells concerned in the production of each kind of body is necessary. But such knowledge of itself falls short, and remains unsatisfactory until it leads up through experiment to an actual control of the phenomena—to the power which can at will conpel the sponge to produce the one or the other kind of reproductive body.

The first of the two new methods to which I have alluded has been described in Science.* It is briefly as follows:

If sponges are kept under appropriate conditions in aquaria, the body dies in some regions, but in localities the cells remain alive and congregate to form masses. In the production of such masses the component cells lose their individuality, fusing with one another to form a continuous mass of protoplasm studded with nuclei (a syncytium). Such masses of syncytial protoplasm are easily seen with the unaided eye scattered through the interior or over the surface of the remains of the original sponge. They are frequently spheroidal, but often of an irregular shape, and have the power of slow amœboid movement. In successful cases of treatment these masses, varying from a fraction of a millimeter to a few millimeters in diameter, are exceedingly abundant. The smaller ones of more regular shape at once call to mind the gemmules that are normally formed in such sponges as *Spongilla*. Experiment shows them to be physiologically like such gemmules in that they have the power to transform into perfect sponges. To bring about this transformation it was only necessary to remove the regenerative masses to the open water of the harbor at Beaufort, where they were kept in small bolting cloth bags suspended in a floating live box. The sponge

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*Wilson, H. V.: A new method by which sponges may be artificially reared. Science, June 7, 1907.

especially worked on was a silicious form, a species of *Stylotella*.*

The second of the two methods, a description of which may be found in the Journal of Experimental Zoölogy,† is the more interesting and important. It should be said that the method succeeds best with sponges in which there is a considerable development of horny skeletal fiber. The form especially used in my work has been *Microciona prolifera* Verrill, and it has proved practically necessary to use always the large bushy specimens. The procedure is as follows:

Cut the sponge into small pieces and put them on a square of bolting cloth. Gather the cloth round the sponge fragments in the shape of a bag. Holding the upper end closed with the fingers, compress the bag repeatedly with small dissecting forceps. The bag meantime remains immersed in a little dish of sea water. The sponge cells are squeezed free of the skeleton and are strained through the pores of the bolting cloth. They fall like a fine sediment on the bottom of the dish. Collect the sediment with a small pipette and strew it over glass plates or shells immersed in sea water. The originally separate cells quickly combine with one another, exhibiting amœboid phenomena. The masses so formed go on fusing with one another through the formation of peripheral pseudopodia, and thus the whole surface of the glass slide (or other object used) may become covered with a network of plasmodial masses and cords, which adhere to it with some firmness. After perhaps half an hour the plate should be lifted from the water and cautiously drained. The sponge plasmodia are thus flattened out somewhat and their attachment to the plate is strengthened. Return the plate at once to a dish of fresh sea water, where it should be left with two or three changes of water for a day. By this time the network of plasmodia has probably transformed itself in whole or in great part into a thin uniform incrustation. It is best now to transfer the

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*Otto Maas has independently discovered that the cells of calcareous sponges under the influence of reagents exhibit a behavior essentially like that above described. See my account in Science, loc. cit.

†Wilson, H. V.: On some phenomena of coalescence and regeneration in sponges. Journal of Experimental Zoology, vol. v. no. 2, December, 1907.

plate to the open water. My practice has been to tie such plates to the inside of galvanized-wire boxes, and to hang the boxes in a large live-box.

In the course of a week it will be found that the incrustation has transformed itself into a functional sponge with pores, oscula, well-developed canal system, and flagellated chambers. The steps in this gradual differentiation may be followed by examining the sponge at intervals under the microscope. The differentiation goes on, but at a slower rate, in preparations kept continuously in laboratory dishes or aquaria. While the sponge incrustation is quite thin, the currents of water and vibrations of the flagella in the flagellated chambers may be observed with a high power. For this purpose small incrustations grown on cover glasses are the best.

Until the past summer it was a question whether sponges produced in this way would continue to grow and would develop the skeleton characteristic of the species. If they would not, it was clear that the method had no value for economic sponge culture. And so, early in July, I again visited the Beaufort laboratory and with the help of my assistant, Mr. R. R. Bridgers, started some *Microciona* plasmodia on glass slides and oyster shells. It was possible for me to remain at the laboratory only two weeks, but Mr. Bridgers took charge of the sponges and continued to start other plasmodia at intervals during July and August, conducting his experiments with great care and skill.

Mishap of course overtook some of the cultures; but scores of them grew perceptibly during the summer and by the first of September a large number had developed the skeleton of the adult with the characteristic spicules and the horny columns projecting up from the basal skeletal plate. What was equally gratifying was that the sponge in many cases had not only spread and thickened and developed the species-skeleton, but had also developed quantities of reproductive bodies. These lay scattered in the deeper part of the incrustation, plainly visible to the eye. I have not yet made a sufficiently precise histological examination of these bodies to determine whether they are egg larvæ or asexual masses. The whole appearance of the sponges grown in this way, some six weeks old, is quite like that of normal *Microciona* of incrusting habit.

Looking from the utilitarian standpoint at this latter method of growing sponges, it is not at all inconceivable that it may at some time be of direct economic value. The ease with which quantities of sponge cells may be had and the opportunity afforded of attaching them to any desired object are considerations which encourage such an idea. Going farther afield from present-day practice and looking to the future, the method suggests itself as one of the possible means of altering the specific characteristics of sponges and improving races. In a paper presented to the National Fishery Congress of 1898* I briefly discussed the possibility of improving sponge races, suggesting as means thereto the breeding of sponges from the egg with accompanying selection, and also the practice of grafting. Now if the cells of two closely allied races were mixed together it is on the whole probable that a composite plasmodium would result which would develop the characteristics of both races. Such a form would be something comparable to a hybrid. I have in fact carried on experiments of this character.† The results of my experiments were negative—the cells of each species coalesced, but there was no permanent union between the cells or cell masses of the different species. It should be said, however, that the species used were so unlike that there was at the outset but little chance of coalescence. In a more favorable locality, where a great variety of horny sponges exist, such experiments hold forth some promise.

NOTE.—In connection with the foregoing paper there was an exhibit of microphotographs illustrating some of the more important stages in the development of sponges from cells forcibly removed from the parent body.

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*Wilson, H. V.: On the feasibility of raising sponges from the egg. Proceedings of the National Fishery Congress, 1898, in U. S. Fish Commission Bulletin, vol. xvii, 1897.

†Journal of Experimental Zoology, loc. cit.

# PECULIARITIES IN THE DISTRIBUTION OF SOME NORTH CAROLINA BIRDS.

By Franklin Sherman, Jr.

In view of the fact that a volume on the birds of North Carolina is already in preparation by Messrs. T. G. Pearson and C. S. Brimley, which will include a few observations made by the writer at various times, it seems desirable to present some of them at this meeting.

A lost or startled bird may wander (or be carried by storm) far out of its natural range. It is not to such accidental circumstances that we wish to refer, but rather to the occurrence of certain birds in nesting season in natural behavior, at localities not generally heretofore known to be within their breeding range.

In the working out of areas of distribution and life-zones, data on the places where a bird nests, are far more valuable than records of its mere occurrence.

SONG SPARROW (*Melospiza fasciata,* Gmel.)

The nesting range of the song sparrow is, in general, northern. Chapman says: "breeds from northern Illinois and Virginia north to Quebec and Manitoba." Curiously enough, all but one of the earliest breeding records for this State were from the coast, indeed, on the very "banks" or fringe of low sandy islands that separate our mainland from the ocean. Mr. Bishop reports that a few breed on Pea Island. Dr. Coues, working chiefly at Fort Macon on the banks at Beaufort, reports that it is a resident (present all the year) though most of them pass north to breed. Mr. Pearson once observed it singing at Cape Hatteras on May 15th. In July, 1906, Mr. Pearson observed it very common at Ocracoke, and he observed it there in other years. These are the eastern records.

The first western North Carolina records are: Three seen frequently in summer of 1892, by Philip Laurent at Cranberry (Mitchell County). Common on Roan Mountain up to 3,500 ft., in June 1895 (S. N. Rhoads). A pair seeen at Asheville July 26, 1902, by T. G. Pearson. Nevertheless, Cairns, who worked for years around Weaverville, in Buncombe County, makes no mention of it, and Mr. Brewster, who gave some time to ornithological study in Haywood, Jackson and Macon counties in May and June 1885, did not list it at all.

The writer is positive that he saw the song sparrow at Highland (Macon County) in the summer of 1903 or 1904, when he crept close to a singing specimen which was exposed to full front view in the top of a small tree, but the fact was not positively recorded, especially as there still existed some doubt of its being in our mountain section in breeding season. The writer had some discussion with our local ornithologists on the subject, which led to a determination to find out the facts.

During the summer of 1907 the writer spent some days at Hendersonville, where he recorded a number for mid-June—and a little later recorded the species at Highlands again. During the same season Mr. S. C. Bruner both saw and collected specimens at Blowing Rock and recorded it as "common." He also found a nest. Immediately after the meeting of our Academy at Greensboro two years ago, Mr. C. S. Brimley and the writer started on a tour of two weeks through the southwestern counties. The species was recorded at Blantyre (Transylvania County), and Highlands, and was collected at Aquone (Macon County). During the same summer (1908) Mr. R. W. Collett working in the Swannanoa Valley near Black Mountain, reported it "as common as the field sparrow. Have never seen but one breeding pair in Cherokee or Graham counties." He reported seeing birds feeding young. June 18 to 24, 1909, the writer observed it to be common at Linville, Linville Falls, Blowing Rock, Boone, Valle Crucis, and Patterson.

Why the status of this bird as a common breeder throughout all the higher parts of our mountain region should have been so long a matter of speculation, is difficult to explain. We consider it common enough now—why did not Cairns or Brewster record it? Possibly it has not always been a common breeder in these sections.

Yet, all through the piedmont and western part of the coastal plain the song sparrow is present only in winter, and goes north in spring to breed. That it should breed in this State only along the very verge of the ocean itself and in our higher mountain localities is worthy of mention.

TOWHEE (*Pipilo erythropthalmus*, Linn.)

This bird is a member of the sparrow family, spends much time on the ground, and is a vigorous scratcher, as might be inferred from its large feet. It is the sort of bird that is apt to be well known in localities where it remains for any length of time. Locally it is sometimes called the "Joe-rigger."

For sometime we have known that the towhee breeds in the mountains in the western part of the State, where it is on record from Hendersonville, Blowing Rock, Highlands, and Buncombe County. On June 9, 1909, Mr. C. S. Bruner observed one at Taylorsville, which is on the verge between the mountains and the piedmont, as it is near the Brushy Mountains, an eastern spur of the Blue Ridge. We have also known that it breeds near the coast. Dr. Coues lists it as a common summer resident at Fort Macon. Dr. J. W. P. Smithwick says it is "ordinarily seen in summer in the east." The writer recorded it as common at White Lake in Bladen County May 18 to 22, 1909, and both Mr. C. S. Brimley and the writer have recorded it at Lake Ellis, Craven County, in May and June in several different years. But we have had no clear and definite records of it in breeding season in the piedmont, unless the Taylorsville record could be so considered.

On July 29, 1908 (midst of breeding season) the writer observed both sexes of the Towhee common on a drive between Stony Ridge, in Stokes County and Stoneville in Rockingham County. So it does at least breed in some sections of piedmont North Carolina.

BARN SWALLOW (*Chelidon erythrogaster*, Bodd.)

Until last year breeding records of the barn swallow were confined to extreme eastern North Carolina, although the great bulk go north of this State to breed. Dr. Bishop and Mr. Pearson record nests on Pea Island. Mr. Pearson reports two nests found at Wrightsville in July, 1903, and the same observer reports two birds seen 15 miles north of Southport in June, 1908.

On July, 20, 1909, the writer observed a pair nesting and in perfectly natural behavior in a barn at Valle Crucis, Watauga County. This locality is at an elevation of 2,500 to 2,700 feet. It is *probable* that it breeds in other localities in at least the northern part of our mountain region.

LOGGERHEAD SHRIKE (*Lanius ludovicianus,* Linn.)

This bird has been known to North Carolina ornithologists chiefly as a winter visitor, arriving from the north in fall, and departing to the northward in spring. Winter records are from Raleigh, Durham, Chapel Hill, Greensboro, Warrenton and Red Springs. Breeding has been recorded from the western half of the State, at Morganton and Statesville. Dr. Smithwick does record it as breeding at LaGrange, though more common as a winter bird.

On April 27, 1909, the writer saw a shrike acting very much at home in a yard at Laurinburg, apparently preparing to nest, as it made frequent trips to the tangle of a scuppernong grape arbor. On July 21, 1909, a pair were observed flying along road and perching on telephone wires at Kelford, in Bertie County, and on July 27 (only six days later) a pair, seemingly mates, were seen at Kingsboro, in Edgecombe County. It seems likely, therefore, that the shrike nests (sparingly perhaps) throughout piedmont and eastern North Carolina.

ROBIN (*Merula migratoria,* Linn.)

This bird is well known to all of us. Of its breeding range Chapman says: "Breeds from near the southern border of the United States northward to the Arctic coast." Nevertheless, it has not until recently been known to nest in eastern North Carolina. Dr. Smithwick in August, 1908 wrote: "I have never seen a robin nesting east of Chapel Hill." His observations were mainly from southeastern Bertie, southeastern Beaufort, and Lenoir counties. At Belvidere, Perquimmans County, Mr. Pearson recorded a pair building April 25, 1898, and in late June, 1909, Mr. C. S. Brimley found the species abundant at Southern Pines and they must have been nesting at that date.

On July, 18, 1909, the writer observed several at Gatesville in the tall shade trees—and on July 30, 1909, observed several in like situation at Grimesland, Pitt County. Several pairs of robins remained in Raleigh through the summer of 1909, and Mr. Brimley has known the species there for many years, in sparing numbers.

From a number of the foregoing records it will be noticed that certain birds, notably song sparow, towhee and barn swallow, are of northern range so far as breeding is concerned, yet they nest along our coast and in the mountains, while all through the central part of the State they are hardly seen at all in breeding season. Yet the mountains, generally speaking, furnish the northern conditions, and the coast furnishes the more southern conditions. Why should a bird of northern tendencies show a preference for the northern and southern extremes of our State and yet seem to shun the great middle ground? It may be noted in this connection that the same peculiarity is shown by certain plants, of which the wild cranberry is an example. This plant grows wild naturally in certain swampy areas in Mitchell County in the west, at altitudes of 3,000 ft. and in the low swamps of Dare and Tyrrell counties in the east, practically at sea-level, yet the plant is not known in all the region between. The same peculiarity has been noted in the distribution of certain mammals.

Mr. W. W. Ashe, who has long studied the plants of the State and their distribution, says that the explanation of these phenomena is that in the coast region the great humidity of the atmosphere reduces the apparent heat to the plant or animal, so that its needs are met as completely as in a more northern latitude.

All of which shows more and more clearly that this State furnishes a fine field for the student of geographical distribution, and the few interesting facts thus far discovered are probably only an indication of many more that are yet hidden.

I am under obligation to Mr. C. S. Brimley for the many records with which mine are here compared. Even my own records were sent direct to Mr. Brimley, who returned them again to me, and at whose suggestion this paper has been prepared.

# A NOTE ON THE DEVELOPMENT OF THE GALL-FLY *DIASTROPHUS NEBULOSUS*, O. S.

By J. D. Ives.

The average number of larvæ taken from blackberry knot galls in January was about 85. But in most of the galls there were places where some of the insects had evidently emerged. In one gall there were as many as 39 such places, while in others there were but few; making the average number of larvæ contained in a gall about 100.

In certain of the galls the number of parasitic or inquilinus larvæ, namely those of *Torymus sackeni,* Ashm., and *Eurytoma sp.* exceeded those of *Diastrophus nebulosus,* O. S. The parasitic larvæ being hairy, were quite easily distinguishable from the hairless larvæ of *Diastrophus,* though nearly the same size, each being about 3 mm. long.

The larvæ of *Diastrophus* began to pupate February 26. A day or so before the larvæ pupated their eyes could be seen through the skin. They appeared as light brownish-pink areas on the second somite of larvæ. The color was in fine pigment spots which gradually enlarged and turned darker as the insect matured. At 2 P. M. I observed a larva about to transform; at 5 P. M. the transformation was complete.

The larvæ of *Torymus* and *Eurytoma* pupated March 5th. At 11 A. M. I noted one larva about to transform. By 11:15 the somites were hardly distinguishable. At the posterior extremity there was a protuberance of the old skin. At 11:30 the size of the protuberance of skin had greatly increased and the head and part of the thorax was free. At 12 the thorax and part of the abdomen were free. By 1:30 the process was complete, though the moulted skin clung to the abdomen for several days. Throughout the process the larva was very active, especially its posterior portion.

By March 11 *Diastrophus* transformed into the adult, while the inquilinus insects transformed March 21.

# COMPOSITION OF SEA WATERS NEAR BEAUFORT, NORTH CAROLINA.*

By Alvin S. Wheeler.

Clarke in his "Data of Geochemistry" reports no analyses of sea waters along the coasts of North America. Possibly no careful analyses have been made. These analyses were undertaken owing to the increasing interest which biologists are taking in the chemical composition of sea water as a feature of the environment of sea life. The work was done during the summer of 1909 at the U. S. Biological Laboratory at Beaufort, N. C., and for the U. S. Bureau of Fisheries. I wish to express here my thanks to the Commissioner of Fisheries, Mr. George M. Bowers, for his courtesy in permitting the publication of my report.

*Sodium and Potassium.* The most careful investigation of sea water has been made by Dittmar, reported in the "Report of the Scientific Results of the Exploring Voyage of H. M. S. Challenger, 1873-1876," Vol. I, Physics and Chemistry. This work was not at hand when this investigation was undertaken and the usual methods for determining sodium and potassium were adopted. These are given in "Mineral Waters of the United States," Bulletin 91, Bureau of Chemistry, by J. K. Haywood and B. H. Smith. The determination of sodium came out low, the total bases being insufficient for the total acids. This experience is in agreement with the statement of Dittmar that "the routine method adopted in mineral salt analysis, i. e., the elimination of lime and magnesia and subsequent joint determination of soda and potash as sulphates or muriates, would never give sufficiently precise results." My determinations were therefore corrected by employing Dittmar's method of "total sulphates." Ten cubic centimeters of water were weighed out in a glass stoppered weighing bottle and evaporated to dryness in a platinum dish with a small excess of sulphuric acid, a dilute solution of known strength being employed. After evaporation to dryness over steam, the residue

*Reprint from The Journal of The Am. Chem. So. May, 1910.

was heated on a sand bath and finally ignited to dull redness to constant weight. The following figures show the value of this method. The values for sodium sulphate by the total sulphate method and by calculation from the determinations of the other constituents differed by two parts in a thousand. On the other hand the values obtained experimentally after elimination of sulphuric acid, lime and magnesia and by calculation from the determinations of the other constituents differed anywhere from thirteen to thirty in a thousand.

*Calcium and Magnesium.* Forty cubic centimeters of water were weighed out and transferred to a beaker. One cc. 5N hydrochloric acid was added and the mixture boiled to expel carbon dioxide. After cooling, four cc. 5N ammonium hydroxide and five cc. N|2 ammonium oxalate solution were added. The next day the supernatant liquid was decanted upon a filter, the residue was redissolved in dilute hydrochloric acid and precipitated with ammonium hydroxide, and a little ammonium oxalate solution. The following day the calcium oxalate was filtered upon the filter already used, washed with hot water and ignited in a platinum crucible to constant weight. The combined filtrates were concentrated to a volume of 150 cc., cooled, mixed with ten cc. normal disodium phosphate solution and ten cc. strong ammonium hydroxide. The next day the precipitate was filtered off, washed with dilute ammonium hydroxide and finally water. It was ignited in an open platinum crucible.

*Chlorine.* Eight cc. sea water were weighed out and transferred to a beaker. Titration was conducted with a standard solution of silver nitrate (one cc.=0.003555 g Cl), using potassium chromate as indicator. In order to better observe the change of tint, a standard of comparison was made by precipitating a sodium chloride solution with excess of silver nitrate and re-establishing the yellow color with a little more salt. The silver nitrate solution was standardized by means of two samples of sodium chloride 1. A sample labelled "Sodium Chloride c. p., Eimer and Amend" was dissolved in pure water and reprecipitated with hydrochloric acid. It was filtered off, washed with water and ignited. 2. A sample labelled "Sodium Chloride c. p. Special. Baker's Analyzed Chemicals." The impurities being CaO=0.001%, Fe=0.0001%, $SO^3$=0.001%.

*Sulphuric Acid.* To 25 cc. sea water which had been weighed, were added while hot 2 cc. dilute hydrochloric acid and 3 cc. N barium chloride solution. The next day the barium sulphate was filtered off, washed with hot water and ignited in a platinum crucible.

*Carbon dioxide.* The determination of carbon dioxide was carried out by titrating 100 g. of water with 0.05 N hydrochloric acid, using phenol-phthalein as indicator for normal carbonates and then methyl orange for bicarbonates. The results were checked by titrating with 0.05 N acid potassium sulphate as recommended by Cameron.

*Specific gravities.* The specific gravities were determined by the use of a picnometer of U form. The temperature employed was that of the laboratory, in order to avoid the usual condensation of moisture on the picnometer if lower temperatures were used.

*The waters.* Five samples of water were analyzed. The localities were marked upon a chart of Beaufort Harbor, which accompanies my report to the Bureau of Fisheries. A. Taken in Beaufort Inlet. B. At the Laboratory dock where water is taken for the Laboratory aquaria. C. In Bogue Sound, opposite Morehead, where *Toxopneustes* are abundant. D. At a point between the eastern end of Beaufort and Bird Island shoal. E. At Green Rock, in Newport River, near the entrance to Core Creek.

The results are given below in four tables. Comparison is made with Dittmar's results. Challenger water No. 924, a deep sea water, is given in three tables, because this is the only water whose composition is reported in parts per thousand of water. It does not, of course, represent the average. For example, the value for chlorine is 55.396 per cent of the total salts, whereas the average for the 76 analyses is 55.420. Comparison is also made with the analysis of a water mentioned in an article by Curt Herbst in "Archiv fur Entwickelungsmechanik der Organismen, Vol. 5, page 651. This water is from the Mediterranean Sea, below Naples, Italy.

TABLE I.

(Parts per 1,000 grams of sea water.)

| | A | B | C | D | E | 924 | Herbst |
|---|---|---|---|---|---|---|---|
| Cl | 19.909 | 19.635 | 19.767 | 19.810 | 17.571 | 19.201 | 21.137 |
| $SO_4$ | 2.754 | 2.681 | 2.699 | 2.730 | 2.378 | 2.673 | 3.237 |
| $CO_3$ | 0.132 | 0.129 | 0.129 | 0.129 | 0.129 | 0.143 | *0.080 |
| Na | 11.049 | 10.968 | 11.022 | 11.036 | 9.771 | 10.607 | 11.936 |
| K | 0.442 | 0.390 | 0.394 | 0.394 | 0.368 | 0.380 | 0.409 |
| Ca | 0.433 | 0.429 | 0.440 | 0.436 | 0.392 | 0.483 | 0.473 |
| Mg | 1.353 | 1.301 | 1.313 | 1.332 | 1.177 | 1.301 | 1.362 |
| Total | 36.072 | 35.533 | 35.767 | 35.867 | 31.786 | 34.788 | 38.634 |

TABLE II.

(Parts per 1,000 grams of sea water.)

| | A | B | C | D | E | 924 | Herbst |
|---|---|---|---|---|---|---|---|
| NaCl | 28.043 | 27.836 | 27.977 | 28.006 | 24.796 | 26.882 | 30.292 |
| KCl | 0.842 | 0.742 | 0.751 | 0.751 | 0.702 | 0.725 | 0.779 |
| $MgCl_2$ | 3.379 | 3.245 | 3.300 | 3.335 | 2.972 | 3.413 | 3.240 |
| $MgSO_4$ | 2.417 | 2.328 | 2.320 | 2.372 | 2.062 | 1.937 | 2.638 |
| $CaSO_4$ | 1.171 | 1.168 | 1.202 | 1.188 | 1.039 | 1.591 | 1.605 |
| $CaCO_3$ | 0.220 | 0.214 | 0.214 | 0.215 | 0.215 | 0.240 | *0.080 |

Total, same as above.

TABLE III.

(Percentage of total salts.)

| | A | B | C | D | E | Dittmar† | Herbst |
|---|---|---|---|---|---|---|---|
| Cl | 55.191 | 55.257 | 55.270 | 55.231 | 55.280 | 55.292 | 54.710 |
| $SO_4$ | 7.635 | 7.546 | 7.547 | 7.612 | 7.481 | 7.692 | 8.380 |
| $CO_3$ | 0.366 | 0.363 | 0.361 | 0.360 | 0.405 | 0.207 | *0.207 |
| Na | 30.630 | 30.867 | 30.818 | 30.768 | 30.741 | 30.593 | 30.894 |

*The residue insoluble in water after evaporation to dryness.

†Average of analysis of Challenger waters.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| K | 1.226 | 1.098 | 1.102 | 1.099 | 1.157 | 1.106 | 1.059 |
| Ca | 1.201 | 1.208 | 1.230 | 1.216 | 1.233 | 1.197 | 1.224 |
| Mg | 3.751 | 3.661 | 3.672 | 3.714 | 3.703 | 3.725 | 3.526 |

Total, 100 per cent.

TABLE IV.

(Percenage of total salts.)

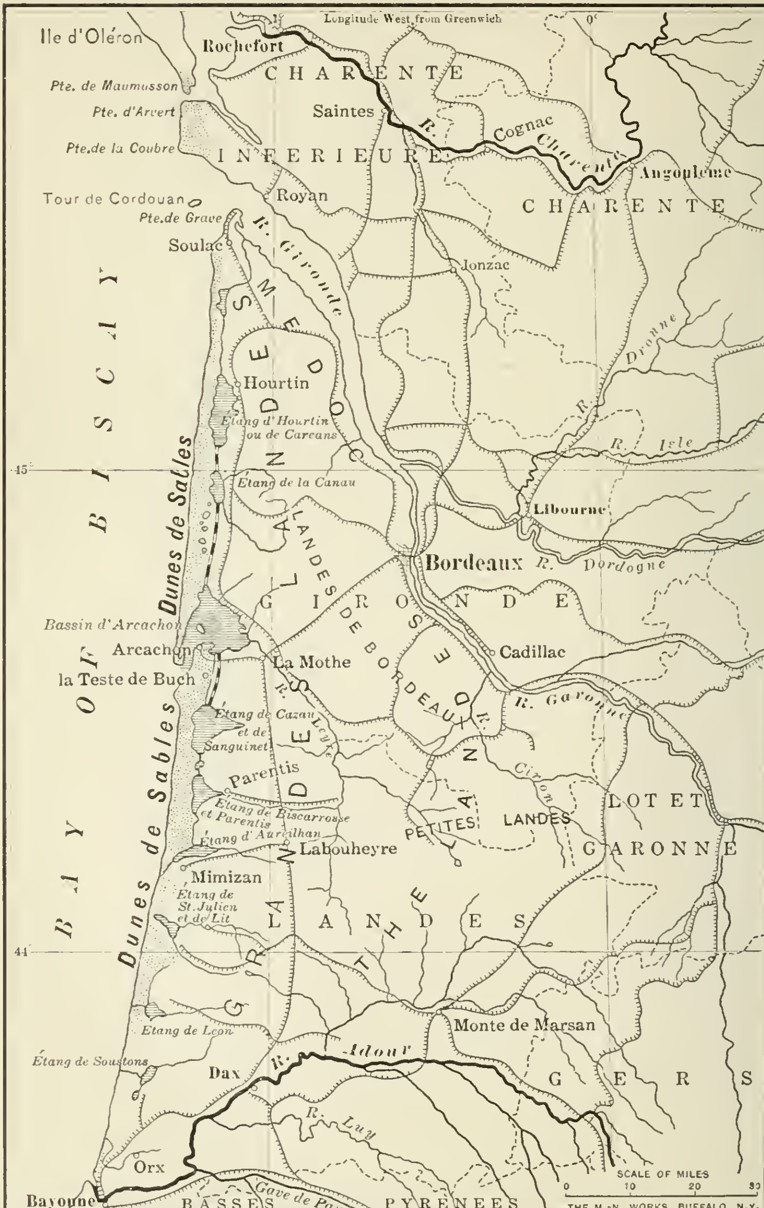
| | A | B | C | D | E | 924 | Herbst |
|---|---|---|---|---|---|---|---|
| NaCl | 77.743 | 78.340 | 78.229 | 78.083 | 78.010 | 77.274 | 78.408 |
| KCl | 2.334 | 2.088 | 2.100 | 2.093 | 2.208 | 2.085 | 2.016 |
| $MgCl_2$ | 9.367 | 9.132 | 9.227 | 9.300 | 9.350 | 9.811 | 8.386 |
| $MgSO_4$ | 6.700 | 6.551 | 6.487 | 6.612 | 6.487 | 5.569 | 6.828 |
| $CaSO_4$ | 3.246 | 3.287 | 3.361 | 3.313 | 3.269 | 4.572 | 4.154 |
| $CaCO_3$ | 0.610 | 0.602 | 0.596 | 0.599 | 0.676 | 0.689 | *0.208 |

Total, 100 per cent.

Specific gravities at 28.7 degrees (corr.)

A. 1.0227; B. 1.0222; C. 1.0226; D. 1.0227; E. 1.0193.

*Insoluble residue.




The Landes and Dunes of Gascony.— Collier Cobb

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## THE LANDES AND DUNES OF GASCONY

BY COLLIER COBB.

Closely resembling our own Atlantic coastal plan in physiographic feattres and in geological history as well, the region known in France as "Les Landes de Gascogne" possesses a peculiar fascination for the traveller who is more than a tourist, to him who would learn how man gains the mastery over nature, instead of remaining a mere creature of his environment and the slave of circumstances.

The French *Landes* extend over the department which takes its name from them, include half of La Gironde, and take in a corner of Lot-et-Garonne, occupying in all about five thousand four hundred square miles, or something less than three and one half million acres. They are bordered on the west by a line of sand-dunes extending along the Bay of Biscay for a hundred and fifty miles, from the river Gironde to the mouth of the Adour at the base of the Pyrenees. This sandy moor is thus bounded by the ocean, the Adour, the cultivated heights of Lot-et-Garonne, and the vineyards of Bordeaux lying along the Gironde.

The region is an old sea-floor, for a long time covered by the waters of the Atlantic and receiving the waste of the land, which was spread with evenness over its area. This has been lifted above sea-level to a height averaging 160 to 190 feet, declining gently on the northeast toward the Gironde and the Garonne, on the west toward the sea-shore lagoons become fresh lakes, and on the south toward the river Adour. The uniformity of this great plain is so marked that highways and railways run prevailingly in straight tangents, and from La Mothe to Labouheyre there is a stretch of the Bordeaux-Bayonne Railway without curve, excavation, or embankment, for twenty-eight miles. The extraordinary retilinear quality of the shore-line is due, first, to the smoothness of The Landes and, second, to the mature action of a powerful sea.

The sands along the coast, and the alluvium bordering the Garonne-Gironde river and that along the Adour as well, are classed by geologist as quaternary; though these sands, those brought down by the rivers and those washed up by the sea, show from their mineral composition that they are derived largely from the pliocene deposits that cover so large a part of the interior. Inland from this coast strip the surface is practically all pliocene, though the streams nearly all cut down to miocene and oligocene; some of them reach eocene, which is seen along the tributaries of the Adour, and others cut down even into the cretaceous. We thus have a heavy series of stratified deposits, clay, sands, and gravels, and a calcareous marl known locally as *tufa*, this last making a bed even more impervious than the *alios*. The clean sands, greater in thickness than any other member of the series, are between the impermeable strata, are water-bearing, and may be reached by deep wells, but not every bed of sand bears water fit to be drunk.

The topographic features of The Landes may be described by calling the region a vast savanna, using the word as it is found today in popular use in the Carolinas, Georgia, and Florida. This extensive sand-flat is so poorly drained that it is nearly everywhere boggy in wet weather, though frequently dry and "crusty" in dry weather. Consequently, Schimper's definition of *savanna*, as xerophilous grass-land with insolated trees, is applicable to even the greater part of this area, since, however boggy it may be, it bears xerophilous vegetation, indicating what the ecologist terms physiological dryness. It is now well recognized by students of soils that drainage may increase the available soil-moisture. When the subsoil is too close and too fully saturated with water to permit the roots of plants to penetrate it, as is the case in The Landes, the roots are forced to develop in so limited an amount of soil, that in time in of drought, when plants demand much moisture because of their rapid growth, capillary action is not able to upply the moisture from below as fast as it is needed, and the re-

Plate I.

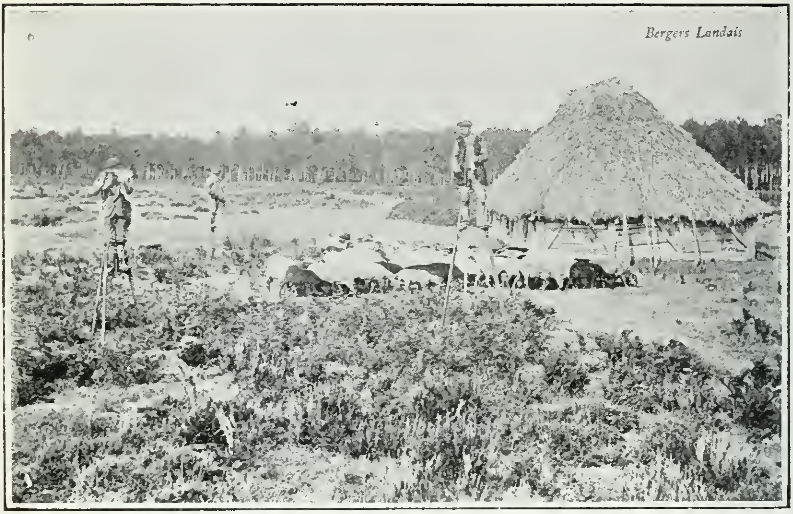


Fig. 1. A View in The Landes.


Fig. 2. An Old Shepherd With His Flock.

Plate II.

Fig. 3. Shepherdesses of The Landes.

Fig. 4. An Old Shepherd of The Landes.

sult is that the stratum of soil occupied by the roots becomes so dry that plant growth is impeded,

The American of our own Southern Atlantic states would describe The Landes as an extensive savanna dotted over with pocosins of considerable size. The pocosins stand at a distinctly higher level than the savanna, and are forested with pines (*P. Pineaster*), though poorly drained. In the larger pocosins there are low places where the water stands in ponds in wet weather. The pocosins have little or no underbrush and are relatively free from flowering plants, while the savanna is covered with shrubs, ferns, the golden-flowered broom, and in spring and autumn is bright with flowers of various hues. When viewed from almost any point, The Landes present a dark horizon-line of pines. There is not an oak, or a beech, or a popular, not a single broad-leaved tree of any kind to be seen on the sandy wastes.

There is also a marked absence of animal life in the region of The Landes.* There is rarely a bird to be seen, except as the sea-birds seek the shelter of the marshes and brackish lakes behind the dunes next the shore. And the quadrupeds are every bit as scarce, except for sheep tended by shepherds and even shepherd-esses. These sheepherders stand above the moor, giants in height, but witches and warlocks for slenderness, being nearly as high as their pole-and-mud huts whose roofs are thatched with rushes. But a second look shows that these tenders of sheep are rather under-sized men and women perched upon stilts that in many cases lift them five feet from the ground.

Besides sheep there are some cattle and an occasional herd of marsh ponies, wild horses like the banker-ponies of the Carolina coast, whose hunting is as much a public ceremonial as the pony-pennings in the neighborhood of Beaufort. And those hunts are now as rare in Gascony as in Carolina, though one may see the little animals anywhere caught and tamed.

The marshy condition of The Landes, consequent upon im-

*This discription applies to the coastal plain portions of Mississippi and Alabama. See Hilgard, Geol. and Agr. Miss., pp. 370-371; Harper, *Torreya*, VI. 204 (Oct. 1906); Hearn and Carr, Soil Survey of Biloxi Area in Field Operations of Bureau of Soils, 1904, pp. 353-374.

perfect drainage, is due chiefly to an impervious layer of compacted sand occuring but a short distance beneath the surface. This agglutinated sand, generally of a rusty color and bearing a close resemblance to ferruginous sandstone, is known as *alios*,† and owes its color and firmness to the continual infiltration of rain-water, which "carries into the ground various organic substances in a state of solution, and blends them intimately with arenaceous particles. (Reclus)." But in the more marshy districts the *alios* is actually a sandstone, in which the cementing material is iron oxide. This bed of *alios* is generally the hardest where it is least thick; it underlies practically the entire area of The Landes, and is completely impervious to water,

The free exit of water from The Landes to the sea is prevented by the combined action of the southward-going shore current, which forms a bar of sand running parallel with the coast from north to south, and the great sand-waves and dunes, marching inward before the prevailing westerly winds, encroaching upon Landes and swamps, and often overwhelming entire villages.

Now the region has been largely drained, and there are fewer solitudes where the Landescot must use stilts to cross the swamps and look after his flocks, this method being confined at the time of my visit, in 1908, to the more remote districts. We are told that before the reclamation of this vast area, "in summer it was a bed of burning sand, in winter in a state of constant inundation, while between the two was a period of pestilence. The country was characterized by steritity and insalubrity." (Gifford)

Then the miles of almost treeless wastes, covered with low dense herbage, were sparsely inhabited. The few people who lived there, depending entirely upon their flocks, were hardly greater in number over the entire area of The Landes than at present in the few insolated districts where the population still retains its primitive character and pastoral occupation, and still speaks a romance dialect more ancient than the *langue d'oc* of much of southern France.

†Like the hardpan of Florida. See Harper in 3d Ann. Rep. Fla. Geol. Survey, pp. 222, 294,295. (1911). Examined in proof.

Plate III.

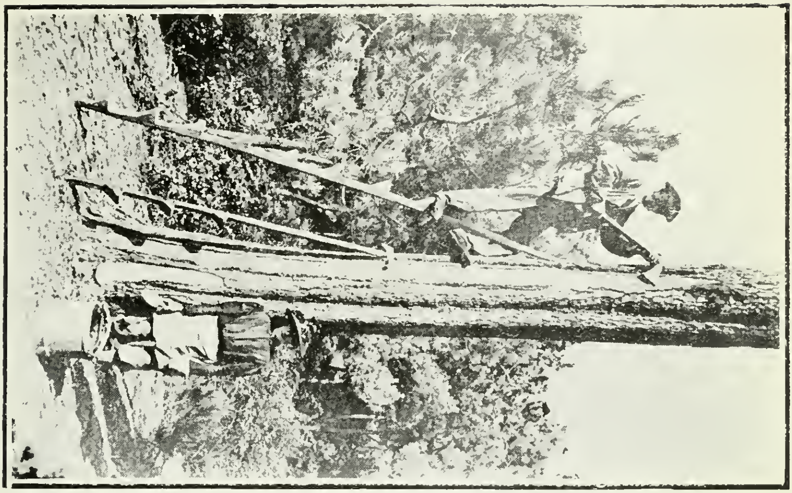

Fig. 5. Resiniers.

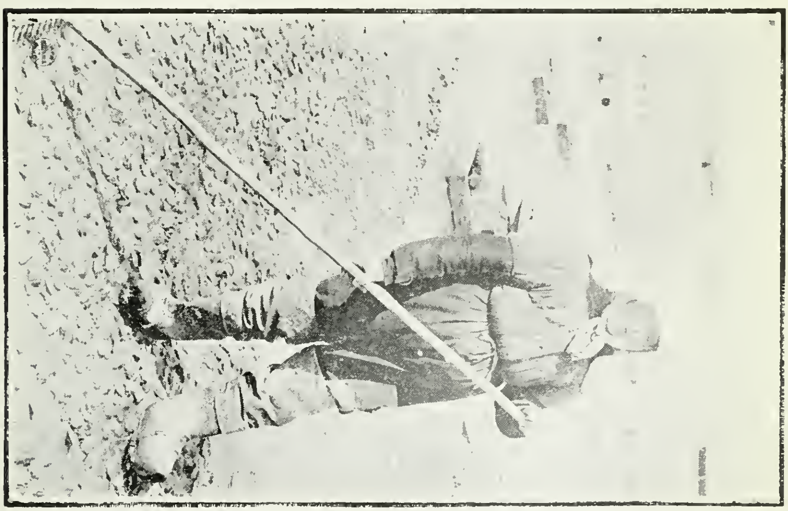

Fig. 6. Une Parqueuse.

Just as on Hatteras Island and along the Banks of the Carolina coast, there are here in the Dunes of Gascony evidences that the roving sands were centuries ago fixed by a natural forest growth. But along both coasts thoughtlessness or vandalism destroyed the forests, and the winds blew the sand inland for a time until grasses followed by woody plants bound the soil in such a way that the winds were powerless to move it. 'In the sand-dunes near Arcachon, five superposed beds of soil are to be traced, containing trunks of trees *in situ* and other remains of vegetation.' (Thoulet)

At one time the dunes threatened to destroy the entire region, for following one destruction of the forests they advanced inland at a rate varying from 60 to 80 feet a year. The village of Lege twice retired before this invasion of sand. Mimizan retreated likewise, and when measures were at length taken to stop the onward march of the dunes they were already within a few yards of its houses. (Reclus).

There are extensive ponds and lagoons in the rear of the dunes, formerly estuaries and bays of the sea from which they became separated by a bar of sand. The streams flowing into and seeping out of them soon leached out the salt and they became living lakes of fresh water. Some of these lakes are rapidly closing up by the growth of plants within their borders, just as Currituck Sound in North Carolina is closing up with vegetation since it became a body of fresh water through the closing of the inlets by drifting sand and the leaching action of its inflowing streams.

The largest of these lakes, the Étang de Cazau, has an area of 15,000 acres, and its surface lies at a level varying from 62 to 66 feet above the level of the sea, according to the season. This feature is very different from our own coast. The rivers draining The Landes and these lakes are turned to the southward on entering the sea, through the action of the southward-going current and the tongues of sand it tends to build across their mouths. It has several times been suggested that the government of France construct a canal running parallel with the coast, lowering the level of this and other lakes, affording a safe waterway connecting the Garonne with the Adour, and avoiding the dangers of the Bay of Biscay with its high winds and violent currents, and several such canals of small size have already been constructed.

Gascony cannot long be without such an inalnd waterway in a country like France, whose rivers have been regulated and deepened so as to render their currents more uniform and permanent. The natural waterways of France have been so supplemented during the last few years by an excellent system of canals that there is hardly any part of the country today that is not reached by water transportation, which has greatly facilitated the exchange of heavy and bulky products, until 42 per cent of the mineral fuel for Paris is now carried into the city by water.

The drainage of these border lakes and swamps has been effected by direct engineering efforts to a much smaller extent than is usually supposed, the most important instance of such effort being that of the Lake of Orx, near Bayonne, which was drained and reclaimed in 1864. We are also told that the efforts of engineers to remove the obstructions to the unimpeded discharge of the rivers have not generally proved successful. The result has come largely from an unforeseen effect of tree planting to be adverted to later.

While it is true that the sands are ever shifting and bars are constantly forming, it is equally well recognized that the sea has been encroaching extensively upon the land. Bremontier states that the sea, in his day, wore away nearly seven feet of the beach of Hourtin annually, and the inhabitants in this day point out traces of man on the narrow edge of this eastern face of the dunes, or on the beach over which the dunes have moved. These are essentially similar to the evidences on the New Jersey coast, consisting of alios, turf-pits, hoof-imprints, trunks of trees still bearing the marks of axes, bricks, and bits of broken pottery.

The retreat of the land along this coast is by no means due entirely to the gnawing of the sea, since there has been a marked subsidence of the land, particularly in the region to the north of the Gironde. The lighthouse of Cordouan, which stands as a beacon for vessels entering this river, was erected by Louis de Foix at the close of the sixteenth century. Then the rock on which it stands was large enough to admit of several dwellings for the workmen employed in its construction. It is now completely

Plate IV.

Fig. 7. Oysterwoman of Arcachon.

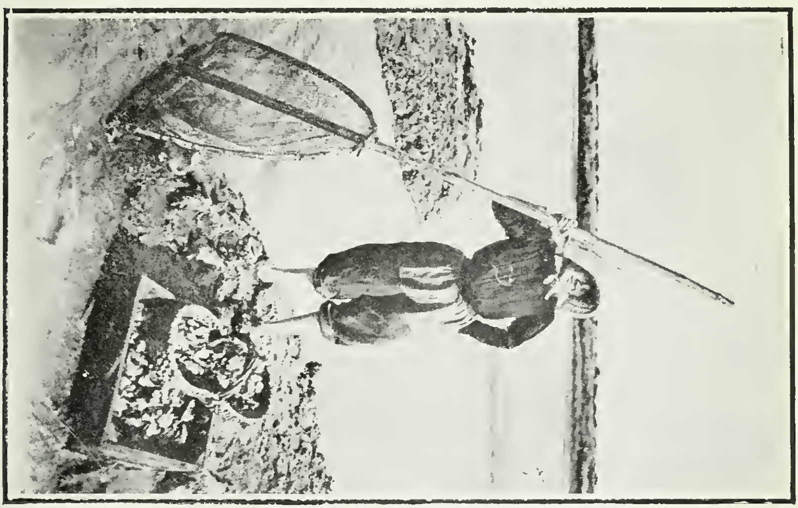

Fig. 8. Une Pecheuse de Crevettes.

covered at high water, and the distance between it and the Point de Grave increased from 3.1 miles in 1630 to 4.3 miles in 1876, according to Reclus, who also tells us of numerous villages, named in old chronicles, that have been swallowed up by the sea or overwhelmed by the inland march of the dunes. "Soulac was an important town on the Gironde, below Bordeaux, whilst the English held the country, but the Gothic church and the few walls which alone remain of it now stand upon the shore of the ocean, the dunes having passed right over them." (Reclus).

The Basin of Arcachon, about half-way between the Adour and the Gironde, is the only estuary on this coast still open to the sea. It is a large depression communicating with the ocean only by a narrow channel, and separated elsewhere by sand-dunes. It, too, will soon be cut off from the sea. Its ever-shifting sands and violent currents are great obstacles to the conversion of this basin into a harbor of refuge, so much needed on this dangerous coast.

The basin is not completely covered. even at high water, but is traversed by various and varying channels due to the violent tidal currents which play such an important part in moulding its features. Since the planting of the shore dunes with maritime pines, this has become the chief center in France for the culture of oysters. But still the Bay of Arcachon is being rapidly filled with sediment, and recourse must be had to dredging if its oyster beds are to be preserved, its neighboring lands saved for agriculture, and its channel kept open to the sea.

When the tide is out this basin presents the appearance of an extensive grass-land, slightly undulating, a vast field of tempting turf. The carts drawn by oxen driven by women over the lawn lend local color to the illusion: and the beholder is ready to believe himself completely bewitched when he sees upon this lawn little schooners and other small sea-going vessels, which are really lying at anchor in the narrow channels of the basin. The carts are gathering the green sea-weed of the flats for manure, and the vessels are waiting for their small cargoes of rosin, turpentine, acid, oysters, shrimps, wool, wooden utensils, or even wines of the finest kinds.

The reclamation of this extensive area has been extremely slow of accomplishment, but the results obtained have paid many fold for the expenditure of time, labor, and money. In 1778, a talented engineer, Baron Charlevoix de Villers, was sent to Arcachon for the purpose of forming a military post. He saw at once the necessity of fixing the sand, and was, according to Grandjean, the first to establish the fact that the way to fix the dunes is by means of plantations of pine. He met with troubles in his work, and was finally sent to the Island of Santo Domingo.

In 1784, Bremontier set to work, and it is said that, by using the results of de Villers's labors, he finally succeeded in fixing the moving sand. This he accomplished by the construction of a littoral dune from the mouth of the Gironde to Bayonne, the winds themselves doing the work under the control of brush fenses planted by the skilled engineer.*

A protective dune was built up to the height of 33 feet, above which height it was observed that the winds did not readily drive the sand inland, provided the dune is at least 300 feet in-shore from high-water mark. The windward slope of the dune is from 4 to 14 degrees, and its leeward slope about 30 degrees. This dune is kept in shape by the growth of grasses upon it, stock is carefully kept off of it, and even man is not allowed to wonder at will over the dunes, lest the wind following in his footsteps set the solid in motion. The French engineers hold firmily to the opinion that the Sahara itself would soon have its oases united and be largely grassed over if wandering Arabs and roaming camels could be fenced out of it.

The dunes next the shore having been fixed, it was nearly fifty years before any further effort was made to reclaim this region of marshes and "miasma." M. Chambrelent, a young engineer of bridges and roads, was sent to the Gironde to study the drainage of 8000,000 hectares† of land in the districts of Gascony and The

*For details as to the methods the reader is referred to the writings of Chambrelent, Grandjean, Poisson, Duffart, and to Dr. John Gifford, especially "The Control of Shifting Sands," in the *Engineering Magazine*, January, 1898.

†A hectare=2.471 acres.

Plate V.


Fig. 9. Protective Dune.


Fig. 10. Forest with Fire Line.

Plate VI.

Fig. 11. A View on the Dunes.

Fig. 12. A View on the Dunes.

Landes. His plans were not accepted, but he was so thoroughly satisfied of their feasibility that he bought some land and applied it to the measures he advocated. In 1855 the results of his experiments were submitted to an international jury, "The jury was so favorably impressed that it recommended the application of Chambrelent's plans to the entire region, and in 1857 a law was passed requiring the Communes to do this work. The Communes paid for it by selling a part of this land [thus improved], which increased in value after the completion of the work."

Drain ditches were dug and seeds of the *Pinus Pinaster* were sown, all the drainage works having been completed in 1865, It was at first feared that the inabilty of the tap-root to penetrate the hardpan would arrest the growth of the trees, "but", says Chambrelent, "the uselessness of the tap-root has already been demonstrated.* It extends to inert soil which receives no atmospheric influence. It really plays only a mechanical role for holding the tree in place, but in close growth is not necessary, because the trees support one another." In several cases, however, the *alios* was pierced with a pick, and wherever the tap-root gained a foothold and went through the hard-pan it maintained underground drainage into the sands beneath, which already drain themselves. If organic substances have been the cementing material, the alios is thus permanently broken up by the drainage which the tap-root effects. Where the hard-pan has become a ferruginous sandstone, the cracks in the rock have been extended by the slow growth of the tap-root; oftentimes the cementing iron oxide has been changed by contact with vegetation to an iron carbonate, which is readily disolved out by the organic acids, and the same result is obtained by a somewhat longer process. An interesting lesson for the forest engineers.

The pines grew with great rapidity, their wood was of superior quality and soon came in great demand in England for mine props and later for telegraph poles, both props and poles being impregnated with copper sulphate before using. In speaking of the

*Many pines on the Miami limestone of Southern Florida have roots speading flat on top of the rock, and have no tap root, to which fact my attention was called by Dr. Roland M. Harper.

effects of the forests, Chambrelent says that "The Landes, which in 1865 were pestilential, are now as free from fever as the most favored regions. The presence of so much wood enables every household to have generous supplies for heating and drying in cold end wet seasons. An investigation of the causes of agricultural depression in other parts of France only too clearly indicates the inestimable benefit of large wood supplies for domestic purposes."

This section is now one of the richest, most productive and most healthful in France, the change having been brought about by the intelligent cultivation of pine forests. Immense forests now cover the country, dunes and marshes are but little in evidence, and the wood, turpentine, rosin, and kindred industries have brought wonderful prosperity to the entire department, which was formerly the most barren district of France. "A man," says Grandjean, "was forced to take some of this land for a debt. He became a millionaire later by selling it in small parcels."

The region is now a famous health resort, combining the beauties and pleasures of the sea-shore with those of the pine forests of the sand-hills. The population of the country has increased in proportion to its natural resources. The fecundity of the people of Gascony is now as proverbial as the alarming sterility of the rest of the French people.

And the old customs are by no means completely destroyed by the coming of the health-seeker and the tourist. The native of The Landes may still be seen standing upon stilts watching his sheep. He balances himself with a staff, whose top is like the top of a crutch, and spends his spare time knitting stockings, even when gossiping with the shepherd of a neighboring flock. The country has improved and the land is no longer desolate; cord-wood is cut from the pocosins and the borders of the pasture-land; but a few of the people still cling to their stilts; in fact, in several places of the back country mail-carriers use stilts today.

The women working in The Landes, the *Échassiéres*, wear skirts; but the wife of the *Résinier*, the *Parqueuse d'huitres*, and the

Plate VII.

Fig. 13. A Resiner's Home.

Fig. 14. Shucking Oysters.

Plate VIII.


Fig. 15. Oyster Boat Manned by Women.

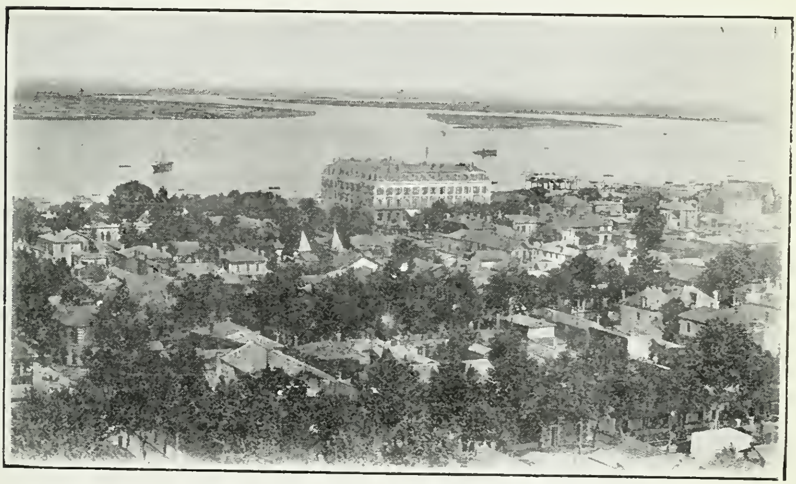

Fig. 16. View of Arcachon, France.

*Pécheuse de crevettes*, women of the forested dunes and of the fisheries, wear trousers of various colors and picturesque patterns.

The revenue of the forests comes mainly from the resin industry, which received a great impetus in its beginning, when similar industries in our Southern States had been disorganized or suspended on account of our Civil War and its blockade. The Hugues cup-and-gutter method of terpentining was then introduced and has been followed there with success ever since. In 1892, the United States Department of Agriculture undertook to introduce the French method into this country, and for a few years following one orchard in Bladen County, North Carolina, was treated in this way. It remained, however, for Dr. Chas. H. Herty to apply the cup-and-gutter to our American pine forests on a commercial scale and with unprecedented financial success, and today the Herty cup, which is used with a gutter specially suited to our method of scarring the trees, is as well known to foresters as the Arcachon method.

The manufacture of rosin, tar, turpentine, pitch, pyroligneous acid, wood vinegar, telegraph poles, fertilizers, etc., are by no means the only industries in this region. The raising of sheep, of cattle, and of small stocky horses, is carried on in The Landes; bees are kept for their delicious honey; the cultivation of oysters, shrimps, and other sea foods, is an important industry along the Bay of Arcachon; and there is some gunning around the lakes. In the industries of the interior man and wife are equal partners in work; but the business activities of the shoreline are almost entirely in the hands of women. The inhabitant of the once dune village is now a citizen of no mean city, Arcachon.

# THE RELATION OF PHARMACOLOGY TO CLINICAL MEDICINE*

BY WM. deB. MACNIDER.

In presenting this subject for your consideration I shall approach it primarily from the standpoint of a teacher, and secondarily from that of a medical man who is deeply interested in the development of scientific clinical medicine in general, and especially interested in its development in the South.

Pharmacology taken in its modern interpretation should be of distinct service to the undergraduate student for its value in scientific training and for its real purpose in demonstrating the mode of action of those drugs which possess such a quality, and equally important for its value in demonstrating the fact that many drugs have no action.

In addition to these self-evident reasons concerning the value of such a course, it may have a broader bearing upon the development of the medical student and upon his future life as a clinician than is usually attributed to it.

It has been my observation at the school with which I am connected and at several other institutions, that when a student completes his first two years of medical work which have to deal with the fundamental and more exact branches of the medical curriculum, that there at once develops, and with some degree of wilfulness on his part, a spirit of forgetfulness for the things of the past and a glowing anticipation for the so-called practical, and in the mind of the student the really useful medical subjects. This attitude means imperfect development so far as the student is concerned and a dwarfed conception of real clinical medicine.

This state of more or less divorce which exists between the first two years of the medical curriculum and the last two, is painfully

*Read by invitation before the Seaboard Medical Society of Virginia and North Carolina.

apparent when we consider the few medical men, comparatively speaking, who approach the cure of disease from the standpoint of structural change, e. g. pathology, and the bare handful in this country. who with an understanding of physiology, attempt a physiological interpretation of a morbidly reacting organism.

There should exist in the latter half of the second year and early in the third year courses whose function it is to bridge this gap and weld together in a fashion inseparable the fundamental branches of the medical curriculum with the more apparently practical branches.

I am aware of the fact that there are perhaps one or more institutions in this country where the type of student is such that this linking is not necessary, but, on the other hand, I believe at those institutions whose prime function it is to turn out general medical men that this union which I have referred to is a real necessity.

At the outset I would have it understood that I am not advocating any system of medical training, or any course which tends to impress the student of its importance by pointing out that the facts learned have a practical value and therefore must be mastered. The highest type of student learns a subject because it is a bit of knowledge to master, and if it contains matter of practical value he is thankful; while if it doesn't he should be glad of his knowledge for learning's own sake. This is the ideal student which happily we run across once in a while. The average student has not such a thirst for knowledge, and for this type, in order to make the most of him, we must lead, enthuse, and in some measure show.

There are two subjects which could if properly handled best fulfil this requirement. They are courses in Pathological Physiology and in Experimental Pharmacology. The proper interpretation and appreciation of symptoms which would be developed in a student who had to think of physiology as a reaction of an organism under morbid influences as contrasted with its reaction under normal influences would be of lasting value to him.

The value of Pharmacology for the purpose mentioned above, depends entirely upon the type of course which is given and upon the amount of expermental work which the student is allowed to attempt.

The type of course in Pharmacology which I have reference to has several characteristics.

In the first place, it should not be chiefly a didactic course. Lectures and quizzes are certainly necessary, but the more lectures can be substituted by observations on the part of the student and the more the quizzes can be eliminated by informal talks and conferences with the student, the better it will be for the course and for the real information gained by the student.

In the second place, a detailed study of a few drugs should be insisted upon and their mode of action and limitations thoroughly mastered. The criterion which determines the efficiency of a drug need not necessarily be its action on the lower animals, though that is certainly the safest guide to rely upon. Some drugs, undoubtedly, are of purely empirical value and have an action which has been established by the careful observations of clinical men. If this be the case, then this drug, and there may be a few, should be learned in a dogmatic way until its value can be determined by showing its mode of action or its inactivity in the lower animals.

On the other hand. it is wrong to use a medical student's valuable time by burdening his intellect with a discussion of useless drugs and trying to "bluff" a mind that should be hunting the truth by discoursing on the value of a substance which has been proved experimentally and clinically to be worthless.

Under the heading of Materia Medica there are at the present many such substances which should not be included in the type of course described. In a measure they are included and have to be, for the reason that examining boards persist in questioning applicants for license concerning such inert substances. Here the boards of Medical Examiners could be of distinct service to teachers of pharmacology and indirectly of service to clinical medicine.

Having selected the drugs, a knowledge of which is the ultimate aim of the course, it next has to be decided in what manner this information is to be imparted. Two plans are available. The subject may be presented in the usual way that such a group of drugs or drug, such for instance as Digitalis is a "heart stimulant and tonic", and by such a presentation simply suffocate any element of inquisitiveness which may be smouldering in the mind of the student. Or another plan of presentation may be used which tends to make him think and reason. The statement may be made that the drug in question influences the heart in two ways: that it has an action on the endings of the vagus nerve in the heart muscle which tends to slow the heart and prolong its diastole; that it has another action on the muscle of the heart, which in part consists in rendering the muscle more irritable and more receptive to outside stimuli. As a result of this increased irritability, a heart under Digitalis action would be faster and more imperfect in its functional capacity were it not for the fact that in the therapeutic stage of Digitalis action the vagus stimulation predominates, slowing the heart and allowing its chambers to more perfectly fill with blood, while with the muscular element being more irritable the systole is prolonged and more perfect. A student with this information will not as a clinician persist in giving increasing doses of Digitalis when the drug which he is administering to slow the heart is the direct cause of its increased rate and imperfect action.

One of the chief aims of such a course is to stimulate inquisitiveness on the part of the student, to make him wonder how the action comes about, with the belief that such a mental attitude will not stop with his student days but will become such a part of his intellectual self that he will carry it directly to the bedside and to the operating room.

After having stimulated in the student this wholesome attitude of doubt and a determination to know the reason for observed facts, the next characteristic of the course is to give him an opportunity to make his own observations and to draw his own deductions.

This is accomplished by allowing the student to work out the action of the more important drugs on the lower animals. This should be the strongest part of the course and should take a part of the time allotted to didactic teaching, and should not be substituted by class demonistrations.

Here, the student administers to an etherized animal Digitalis for instance, and obtains a record of slow heart, what is the cause of the slowing? Is it an inhibitary action on the part of the vagus, is it diminished activity on the part of the sympathetic or is it a less irritable heart muscle? He likely knows from his didactic study that Atropine depresses and finally paralyses the endings of many nerves, he administers this drug or cuts the vagi and the rate of the heart increases. He has observed the action in this instance of a given substance, e. g. Digitalis; he has wondered at its action and formulated certain possible conditions which could have brought about the result; next, he has determined which one of these possibilities really exists; finally, he has found the truth.

The foregoing is a concrete example of the type of training which experimental pharmacology offers. A student who has such training, provided there is enough of it, is bound to develoy a thinking, reasoning mind which will carry the more exact training of the elementary branches of the medical curriculum unconsciously into the clinical branches and persistently ask the reason why.

# ON SURFACE ENERGY AND SURFACE TENSION*

BY J. E. MILLS AND DUNCAN MACRAE.

In an article by Whittaker[1] "On the Theory of Capillarity," it was shown that the following empirical relation was apparently true: *The surface energy of a liquid in contact with its own vapor at any temperature is proportional to the product of the internal latent heat and the (absolute) temperature.*"

The proposed relation and further related applications and inference have since been discussed by Kleeman in a number of papers.[2]

Some explanation of the relation proposed is perhaps necessary. Particles in the interior of a liquid are attracted by the surrounding molecules equally in every direction; but particles on, or near, the surface are attracted only, or as a resultant, inward, in a direction perpendicular to the surface. When the area of the surface of the liquid is increased, work is therefore done against the molecular forces in bringing additional molecules within the surface layer. If the surface of a liquid is actually increased—as in blowing a soap bubble—it will be found that as the surface increases in size under the action of the externally supplied force (the pressure of the air blown within the bubble), the surface layer of the liquid becomes at the same time colder. Heat is absorbed from the surrounding bodies in order to raise the temperature of the surface film to the initial temperature. Therefore the total energy necessary to increase the surface area is supplied partly as mechanical (external) work and partly as heat energy. If $E$ represents the total energy per square centimeter of surface

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*Reprinted from the Journal of The American Chemical Sotiety, Vol. XXXII, No. 10. October, 1910.

[1] *Proc. Roy. Soc.*, **81**, 21 (1908).

[2] *Phil. Mag.*, **18**, 39, 491, 901 (1909); **19**, 783 (1910).

layer, $\gamma$, the necessary mechanical work performed in making this surface, and $T$ the absolute temperature, we have from Helmholtz's free energy equation the relation first stated by Lord Kelvin,

$$1. \qquad E = \gamma - T\frac{d\gamma}{dT},$$

where—$T\,d\gamma / dT$ represents the amount of heat energy absorbed from the surrounding bodies. The mechanically supplied surface unergy, $\gamma$, in ergs per square centimeter, is numerically equal to the surface tension per linear centimeter in dynes.

The heat of vaporization necessary to change a liquid into a vapor is expended in two ways: *first*, in pushing back the external pressure as the liquid expands, and *second*, in doing certain internal work within the liquid. The first amount of energy is easily calculated and when substracted from the total leaves the so-called "internal heat of vaporization." This internal heat of vaporization, $\lambda$, can be calculated from the thermodynamical relation discovered by Clausius and Clapeyron,

$$2. \qquad \lambda = (T\frac{dP}{dT} - P)\ (V - v);$$

here $P$ denotes the vapor pressure, and $v$ and $V$ denote the volume of liquid and its saturated vapor, respectively.

The proposed relation of Whittaker states that

$$3. \qquad \frac{E}{T\lambda} = \text{constant}$$

where $E$ is obtained from equation 1 and $\lambda$ from equation 2.

Whitaker himself stated that the above empirical relation, being yet without theoretical basis, and being based only on the behavior of five substances over a limited range of temperature, must be received with caution until further comparison with experimental results was possible.

It seemed to the authors desirable, for the reasons mentioned below, to re-examine the experimental basis for the proposed relation.

*First*—The values of the internal heat of vaporization used by Whittaker were taken from a paper by one of us[1] and these values

[1] Mills *J. Phys. Chem.*, **8**, 383 (1904); **10**, 1 (1906).

have been lately revised. The revision was made necessary by the changes made by Dr. Sidney Young in the orignal data used for the calculation of these values. These changes were usually small, but extensive, and affected principally the volumes of the saturated vapor at the lower temperatures and the vapor pressure.[2]

*Second*—Whittaker, due to the increasing uncertainy in the values for the internal heat of vaporization, and in $d\gamma / dT$ as the critical temperature was approached, did not extend his study of the relation given in equation 3 nearer the critical temperature than 40 or 50°. While it is true that the data become increasingly uncertain, it is also true that $\lambda$, $E$, $\gamma$ and $d\gamma / dT$, when plotted against the temperature, give nearly straight lines over the range of temperature investigated by Whittaker. It becomes of very greatly increased importance therefore to carry the study of equation 3 nearer the critical temperature.

*Third.*—Whittaker obtained his values of $d\gamma / dT$ from the values for $\gamma$ as given by Ramsey and Shields.[3] Now they concluded from an apparently sufficient experimental basis that the surface tension, $\gamma$, could be expressed for non-associated liquids, as were those investigated by Whittaker, by the equation

$$4. \qquad \gamma(Mv)^{2/3}=k(\tau-d),$$

where $\tau$ represents degrees counted from the critical temperature, and $k$ and $d$ are constants, $k$ being approximately 2.12, and $d$ varying with the different substances investigated from 5.9 to 8.5. $Mv$ is the molecular volume of the liquid. Equation 4 is true nearly to the critical temperature, and it is clear that the function $-d\gamma / dT$ must therefore decrease continuously and consistently with increase of temperature; that is, for non-associated liquids $-d\gamma / dT$, when plotted against the temperature, must neither increase nor give a line of double curvature. An examination of the values of $d\gamma / dT$ given by Whittaker for carbon tetrachloride, benzene, and chlorobenzene show that his values do not strictly obey the above statement and seem too greatly influenced by the

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[2]Arrhenius number of *Z. physik. Chem.*, **70**, 620 (1910). *Scientific Proc. Roy. Dublin Soc.*, **12**, 374 (1910).

[3]*Phil. Trans. Roy. Soc.*, **184**A, 647 (1893).

individual errors of observation. We have changed, therefore, in the tables below, usually very slightly, some of the values of $d\gamma/dT$ as given by Whittaker for the above-mentioned substances.

Whittaker states on page 23 of the article cited that "A point is at length reached, about 180° below the critical point, at which $E$ is stationary, and thenceforward $E$ diminishes as the temperature decreases—a somewhat surprising result. These changes in $E$ are identical with the changes of the function $T\lambda$, which has its stationary point at the same temperature as $E$." We consider this statement to be in error as regards the behavior of the surface energy so far as non-associated liquids are concerned. The remark seems true for associated liquids. For confirmation of our point of view it is sufficient to cite the form of the surface tension curves as shown in the paper by Ramsay and Shields, and the values of the internal heat of vaporization as given in the papers by Mills already cited.

*Fifth*—We found data available for a study also of ethyl acetate, and for the supposedly associated liquids, water, acetic acid, and methyl and ethyl alcohols.

The data and the results obtained are given in the tables below. The surface tension, $\gamma$, was obtained from the measure, ments of Ramsay and Shields.[1] The values of $d\gamma/dT$ were derived from the measurements of $\gamma$ given, and were smoothed in accordance with the observations above made. The values of $d\gamma/dT$ given by Whittaker were used for ethyl ether and methyl formate at the lower temperatures, and his values were not greatly changed for carbon tetrachloride and benzene, The values for $E$ were obtained from the data given by the use of equation 1.

TABLE 1.—ETHYL OXIDE.

| $t$°C. | $\gamma$. | $-d\gamma/dT$ | $E$. | $\lambda$. | $10^4E/T\lambda$. |
|---|---|---|---|---|---|
| 20 | 16.49 | .... | .... | 80.04 | .... |
| 40 | 14.05 | 0.112 | 49.1 | 75.02 | 20.9 |
| 50 | 12.94 | 0.1115 | 48.9 | 72.66 | 20.8 |
| 60 | 11.80 | 0.110 | 48.4 | 70.40 | 20.6 |
| 70 | 10.72 | 0.108 | 47.8 | 67.81 | 20.6 |

[1] *Phil. Tras.*, **184**A, 647 (1893); *Z. physik. Chem.*, **12**, 433 (1893).

| | | | | | |
|---|---|---|---|---|---|
| 80 | 9.67 | 0.106 | 47.1 | 65.40 | 20.4 |
| 90 | 8.63 | 0.1035 | 46.1 | 62.89 | 20.2 |
| 100 | 7.63 | 0.1015 | 45.5 | 60.40 | 20.2 |
| 110 | 6.63 | 0.0995 | 44.7 | 57.53 | 20.3 |
| 120 | 5.65 | 0.097 | 43.8 | 54.53 | 20.4 |
| 130 | 4.69 | 0.094 | 42.6 | 51.43 | 20.6 |
| 140 | 3.77 | 0.0905 | 41.1 | 48.13 | 20.7 |
| 150 | 2.88 | 0.086 | 39.3 | 44.30 | 21.0 |
| 160 | 2.08 | 0.080 | 36.7 | 39.81 | 21.3* |
| 170 | 1.33 | 0.071 | 32.8 | 34.31 | 21.6* |
| 180 | 0.64 | 0.058 | 26.9 | 27.36 | 21.7* |
| 185 | 0.38 | 0.0495 | 23.0 | 22.99 | 21.8* |
| 190 | 0.16 | 0.040 | 18.7 | 16.59 | 24.3* |
| 193 | 0.04 | .... | .... | 9.71 | .... |
| 193.8 | 0 | .... | .... | 0 | .... |
| 190 | Mills | .... | .... | 17.68 | 22.8* |
| 190 | Dieterici | .... | .... | 17.44 | 23.2* |

values given for $\lambda$ were calculated by Mills and have been partially published.[1] Details and references will be found in that paper. The complete data will be publised later.

We have, except for the alcohols, averaged the values of the constant $10^4E/T\lambda$ for each substance down to the values marked with an asterisk, and have marked with an asterisk all values differing from the mean values so obtained by more than 3 per cent. The mean values are given in Table XI.

Considering first the non-associated substance, it will be seen that the "constant" decreases to the extent of 3 per cent. or more from its value at the lowest temperature to a medium value, and then rises in value until the critical temperature is reached. This consistant behavior of the constant tends strongly to show that it is not a true constant. A closer examination of the data tends to confirm this belief.

*For the divergence of the "constant" from constancy cannot be due to the values used for the internal heats of vaporization.* One of us has made an extended and close study[2] of the internal heat of vaporization both of the substances at present under investigation and of other substances. From the discussion and data given in

[1] THIS JOURNAL, **31**, 1099 (1909).

[2] Mills, *Ibid.*, **31**, 1099 (1909). *J. Phys. Chem.*, **13**, 512 (1909)

TABLE II.—CARBON TETRACHLORIDE.

| $t$°C. | $\gamma$. | $-d\gamma/dT$. | $E$. | $\lambda$. | $10^4E/T\lambda$. |
|---|---|---|---|---|---|
| 20 | 25.68 | .... | .... | .... | .... |
| 80 | 18.71 | .... | .... | 41.64 | .... |
| 90 | 17.60 | 0.1115 | 58.1 | 40.72 | 39.3* |
| 100 | 16.48 | 0.110 | 57.5 | 39.64 | 38.9 |
| 110 | 15.41 | 0.1085 | 57.0 | 38.53 | 38.6 |
| 120 | 14.32 | 0.107 | 56.4 | 37.48 | 38.3 |
| 130 | 13.27 | 0.105 | 55.6 | 36.35 | 38.0 |
| 140 | 12.22 | 0.103 | 54.8 | 35.27 | 37.6 |
| 150 | 11.21 | 0.1015 | 54.1 | 34.19 | 37.4 |
| 160 | 10.22 | 0.100 | 53.5 | 33.28 | 37.2 |
| 170 | 9.24 | 0.098 | 52.6 | 32.21 | 36.9 |
| 180 | 8.26 | 0.0965 | 52.0 | 30.83 | 37.2 |
| 190 | 7.28 | 0.095 | 51.3 | 29.52 | 37.5 |
| 200 | 6.34 | 0.093 | 50.3 | 28.22 | 37.7 |
| 210 | 5.40 | 0.0915 | 49.6 | 26.83 | 38.3 |
| 220 | 4.47 | 0.090 | 48.8 | 25.35 | 39.0 |
| 230 | 3.56 | 0.0870 | 47.3 | 23.73 | 39.6* |
| 240 | 2.74 | 0.0825 | 45.1 | 21.91 | 40.1* |
| 250 | 1.93 | 0.076 | 41.7 | 19.85 | 40.2* |
| 260 | 1.20 | 0.067 | 36.9 | 17.15 | 40.4* |
| 270 | 0.59 | .... | .... | 13.62 | .... |
| 283.15 | 0 | .... | .... | 0 | .... |
| 260 | Mills | .... | .... | 16.78 | 41.2* |
| 260 | Dieterici | .... | .... | 16.97 | 40.8* |

TABLE III.—BENZENE.

| $t$°C. | $\gamma$. | $-d\gamma/dT$. | $E$. | $\lambda$. | $10^4E/T\lambda$. |
|---|---|---|---|---|---|
| 80 | 20.28 | 0.116 | 61.2 | 86.70 | 20.0 |
| 90 | 19.16 | 0.116 | 61.3 | 84.69 | 19.9 |
| 100 | 18.02 | 0.116 | 61.3 | 82.37 | 20.0 |
| 110 | 16.86 | 0.115 | 60.9 | 79.98 | 19.9 |
| 120 | 15.71 | 0.1145 | 60.7 | 77.39 | 20.0 |
| 130 | 14.57 | 0.1125 | 59.9 | 75.45 | 19.7 |
| 140 | 13.45 | 0.1105 | 59.1 | 73.45 | 19.5 |
| 150 | 12.36 | 0.108 | 58.0 | 71.34 | 19.2 |
| 160 | 11.29 | 0.106 | 57.2 | 69.48 | 19.0 |
| 170 | 10.20 | 0.104 | 56.3 | 67.25 | 18.9 |
| 180 | 9.15 | 0.102 | 55.4 | 65.21 | 18.8 |
| 190 | 8.16 | 0.100 | 54.5 | 62.51 | 18.8 |
| 200 | 7.17 | 0.098 | 53.5 | 59.75 | 18.9 |
| 210 | 6.20 | 0.096 | 52.6 | 57.04 | 19.1 |
| 220 | 5.25 | 0.094 | 51.5 | 53.76 | 19.4 |
| 230 | 4.32 | 0.091 | 49.9 | 50.30 | 19.7 |

| | | | | | |
|---|---|---|---|---|---|
| 240 | 3.41 | 0.087 | 48.1 | 46.53 | 20.1* |
| 250 | 2.56 | 0.083. | 46.0 | 42.46 | 20.7* |
| 260 | 1.75 | 0.0785 | 43.6 | 37.55 | 21.8* |
| 270 | 0.99 | 0.073 | 40.6 | 31.49 | 23.7* |
| 275 | 0.66 | .... | .... | .... | .... |
| 280 | 0.29 | .... | .... | 23.45 | .... |
| 288.5 | 0 | .... | .... | 0 | .... |
| 270 | Mills | ... | .... | 31.47 | 23.7 |

Dieterici not calculated at 270°, but at 260° = 37.52 and at 280° = 23.79.

TABLE IV.—CHLOROBENZENE.

| $t$°C. | $\gamma$. | $-d\gamma/dT$. | $E$. | $\lambda$. | $10^4E/T\lambda$. |
|---|---|---|---|---|---|
| 159 | 17.67 | 0.100 | 60.0 | 65.45 | 21.7 |
| 160 | 16.62 | 0.0995 | 59,7 | 64.14 | 21.5 |
| 170 | 15.67 | 0.0995 | 59.8 | 62.87 | 21.5 |
| 180 | 14.66 | 0.099 | 59.5 | 61.67 | 21.3 |
| 190 | 13.69 | 0.0985 | 59.3 | 60.06 | 21.3 |
| 200 | 12.72 | 0.0970 | 58.6 | 58.50 | 21.2 |
| 210 | 11.75 | 0.0960 | 58.1 | 56.87 | 21.1 |
| 220 | 10.81 | 0.0945 | 57.4 | 55.55 | 21.0 |
| 230 | 9.88 | 0.093 | 56.7 | 53.90 | 20.9 |
| 240 | 8.94 | 0.0915 | 55.9 | 52.25 | 20.9 |
| 250 | 8.04 | 0.090 | 55.1 | 50.37 | 20.9 |
| 260 | 7.14 | 0.0875 | 53.8 | 48.17 | 21.0 |
| 270 | 6.27 | 0.0855 | 52.7 | 45.80 | 21.2 |
| 280 | 5.40 | 0.0825 | .... | .... | .... |
| 290 | 4.54 | 0.080 | .... | .... | .... |
| 300 | 3.79 | 0.0765 | .... | .... | .... |
| 310 | 3.05 | 0.073 | .... | ... | .... |
| 320 | 2.35 | 0.069 | .... | .... | .... |
| 333 | 1.47 | .... | .... | .... | .... |
| 359.1 | 0 | .... | .... | .... | .... |

TABLE V.—METHYL FORMATE.

| $t$°C. | $r$. | $-dr/dT$. | $E$. | $\lambda$ | $10^4E/T\lambda$. |
|---|---|---|---|---|---|
| 20 | 24.62 | .... | .... | .... | .... |
| 30 | 23.09 | 0.153 | 69.4 | 104.38 | 21.9 |
| 40 | 21.56 | 0.151 | 68.8 | 101.16 | 21.7 |
| 50 | 20.05 | 0.149 | 68.2 | 98.18 | 21.5 |
| 60 | 18.58 | 0.147 | 67.5 | 94.74 | 21.4 |
| 70 | 17.15[1] | 0.145 | 66.9 | 91.43 | 21.3 |

[1] Misprinted in the original paper by Ramsay and Shields.

| | | | | | |
|---|---|---|---|---|---|
| 80 | 15.70 | 0.143 | 66.2 | 88.31 | 21.2 |
| 90 | 14.29 | 0.141 | 65.5 | 85.25 | 21.2 |
| 100 | 12.90 | 0.139 | 64.6 | 81.83 | 21.2 |
| 110 | 11.52 | 0.1365 | 63.8 | 78.96 | 21.1 |
| 120 | 10.18 | 0.134 | 62.9 | 75.87 | 21.1 |
| 130 | 8.86 | 0.1315 | 61.8 | 71.95 | 21.3 |
| 140 | 7.54 | 0.128 | 60.4 | 68.10 | 21.5 |
| 150 | 6.30 | 0.124 | 58.8 | 64.03 | 21.7 |
| 160 | 5.06 | 0.119 | 56.6 | 59.28 | 22.0 |
| 170 | 3.90 | 0.1125 | 53.7 | 54.41 | 22.3* |
| 180 | 2.81 | 0.105 | 50.4 | 48.64 | 22.9* |
| 190 | 1.78 | 0.096 | 46.2 | 41.93 | 23.8* |
| 200 | 0.87 | 0.086 | 41.5 | 33.18 | 26.5* |
| 210 | 0.06 | .... | .... | 19.58 | .... |
| 214.0 | 0 | .... | .... | 0 | .... |
| 200 | Mills | .... | .... | 35.10 | 25.0* |
| 200 | Dieterici | .... | .... | 35.04 | 25.0* |

TABLE VI.—ETHYL ACETATE.

| $t°C.$ | $r.$ | $-dr/dT.$ | $E.$ | $\lambda$ | $10^4E/T\lambda.$ |
|---|---|---|---|---|---|
| 20 | 23.60 | .... | .... | .... | .... |
| 80 | 16.32 | 0.1185 | 58.1 | 78.25 | 21.1 |
| 90 | 15.14 | 0.117 | 57.6 | 76.40 | 20.8 |
| 100 | 13.98 | 0.115 | 56.9 | 74.36 | 20.5 |
| 110 | 12.84 | 0.113 | 56.1 | 72.13 | 20.3 |
| 120 | 11.75 | 0.111 | 55.4 | 69.64 | 20.2 |
| 130 | 10.66 | 0.109 | 54.6 | 66.84 | 20.3 |
| 140 | 9.57 | 0.107 | 53.8 | 64.42 | 20.2 |
| 150 | 8.52 | 0.1045 | 52.7 | 61.38 | 20.3 |
| 160 | 7.48 | 0.1025 | 51.9 | 58.36 | 20.5 |
| 170 | 6.47 | 0.100 | 50.8 | 55.71 | 20.6 |
| 180 | 5.51 | 0.097 | 49.4 | 52.68 | 20.7 |
| 190 | 4.54 | 0.093 | 47.6 | 49.48 | 20.8 |
| 200 | 3.64 | 0.089 | 45.7 | 46.11 | 21.0 |
| 210 | 2.80 | 0.0835 | 43.1 | 42.08 | 21.2 |
| 220 | 1.96 | 0.077 | 39.9 | 37.11 | 21.8* |
| 230 | 1.18 | 0.069 | 35.9 | 31.32 | 22.8* |
| 240 | 0.49 | 0.060 | 31.3 | 23.55 | 25.9* |
| 245 | 0.21 | .... | .... | 18.00 | .... |
| 250.1 | 0 | .... | .... | 0 | .... |
| 240 | Mills | .... | .... | 24.78 | 24.6* |
| 240 | Dieterici | .... | .... | 24.32 | 25.1* |

the papers cited we feel certain that the heats of vaporization given are correct to within 2 per cent. except as the critical temperature is approached. Nearly always they are correct to within 1 per cent. Now as the critical temperature is approached, it is true, as shown in the papers cited, that the internal heat of vaporization as usually calculated by the use of equation 2, and as given in this paper, is too small. But the error thus caused is not nearly so great enough to account for the great increase in the value of the constant. For it was further

TABLE VII.—WATER.

| $t$°C. | $r$. | $dr/dT$. | $E$. | λ | $10^4E/T\lambda$ |
|---|---|---|---|---|---|
| 0 | 73.21 | 0.122 | 106.5 | 565.0 | 6.90 |
| 10 | 71.94 | 0.131 | 109.0 | 559.3 | 6.89 |
| 20 | 70.60 | 0.1385 | 111.2 | 552.5 | 6.87 |
| 30 | 69.10 | 0.1475 | 113.8 | 545.8 | 6.88 |
| 40 | 67.50 | 0.155 | 116.0 | 539.2 | 6.88 |
| 50 | 65.98 | 0.162 | 118.3 | 532.4 | 6.88 |
| 60 | 64.27 | 0.168 | 120.2 | 525.4 | 6.87 |
| 70 | 62.55 | 0.174 | 122.2 | 518.4 | 6.87 |
| 80 | 60.84 | 0.179 | 124.0 | 511.4 | 6.87 |
| 90 | 58.92 | 0.1835 | 125.5 | 504.5 | 6.85 |
| 100 | 57.15 | 0.188 | 127.3 | 497.1 | 6.87 |
| 110 | 55.25 | 0.192 | 128.8 | 489.2 | 6.87 |
| 120 | 53.30 | 0.196 | 130.3 | 481.0 | 6.89 |
| 130 | 51.44 | 0.200 | 132.0 | 472.9 | 6.92 |
| 140 | 49.42 | 0.204 | 133.7 | 465.0 | 6.96 |

TABLE VIII.—ACETIC ACID.

| $t$°C. | $r$. | $-dr/dT$ | $E$. | λ | $10^4E/T\lambda$ |
|---|---|---|---|---|---|
| 20 | 23.46 | .... | .... | 79.17 | .... |
| 130 | 16.18 | 0.083 | 49.6 | 85.09 | 14.5 |
| 140 | 15.32 | 0.085 | 50.4 | 83.62 | 14.6 |
| 150 | 14.46 | 0.0865 | 51.0 | 82.37 | 14.6 |
| 160 | 13.58 | 0.088 | 51.7 | 81.14 | 14.7 |
| 170 | 12.71 | 0.089 | 52.1 | 81.85 | 14.4 |
| 180 | 11.77 | 0.090 | 52.5 | 79.01 | 14.7 |
| 190 | 10.93 | 0.091 | 53.1 | 77.97 | 14.7 |
| 200 | 10.05 | 0.092 | 53.6 | 76.72 | 14.8 |
| 210 | 9.11 | 0.0923 | 53.7 | 75.32 | 14.8 |
| 220 | 8.22 | 0.0927 | 53.9 | 73.25 | 14.9 |
| 230 | 7.28 | 0.0930 | 54.1 | 71.44 | 15.0 |

| | | | | | |
|---|---|---|---|---|---|
| 240 | 6.36 | 0.0930 | 54.1 | 69.54 | 15.1 |
| 250 | 5.40 | 0.0930 | 54.0 | 67.05 | 15.4* |
| 260 | 4.48 | 0.0915 | 53.2 | 64.00 | 15.6* |
| 270 | 3.59 | 0.0885 | 51.6 | 60.37 | 15.8* |
| 280 | 2.71 | 0.084 | 49.2 | 55.97 | 15.9* |
| 290 | 1.92 | 0.0785 | 46.1 | 50.32 | 16.3* |
| 300 | 1.16 | 0.0710 | 41.8 | 42.97 | 17.0* |
| 310 | 0.49 | .... | .... | 33.06 | .... |
| 320 | 0.32 | .... | .... | 18.27 | .... |
| 321.65 | 0 | .... | .... | 0 | .... |

TABLE IX.—METHYL ALCOHOL.

| $t$°C. | $r$. | $-dr/dT$. | $E$. | $\lambda$ | $10^4E/T\lambda$ |
|---|---|---|---|---|---|
| 20 | 23.02 | .... | .... | 266.5 | .... |
| 70 | 17.64 | .... | .... | 244.4 | .... |
| 80 | 16.70 | 0.0905 | 48.6 | 238.5 | 5.77 |
| 90 | 15.72 | 0.093 | 49.5 | 232.1 | 5.87 |
| 100 | 14.80 | 0.0955 | 50.4 | 225.2 | 6.00 |
| 110 | 13.85 | 0.098 | 51.4 | 218.3 | 6.14 |
| 120 | 12.88 | 0.1005 | 52.4 | 211.0 | 6.32 |
| 130 | 11.84 | 0.103 | 53.3 | 203.2 | 6.51 |
| 140 | 10.79 | 0.1055 | 54.4 | 195.4 | 6.74 |
| 150 | 9.77 | 0.108 | 55.4 | 185.6 | 7.06 |
| 160 | 8.65 | 0.1105 | 56.5 | 178.2 | 7.32 |
| 170 | 7.53 | 0.113 | 57.6 | 168.5 | 7.71 |
| 180 | 6.41 | 0.1155 | 58.7 | 158.1 | 8.19 |
| 190 | 5.23 | 0.117 | 59.4 | 147.5 | 8.70 |
| 200 | 4.05 | 0.117 | 59.4 | 134.9 | 9.31 |
| 210 | 2.93 | 0.114 | 58.0 | 119.5 | 10.05 |
| 220 | 1.80 | 0.108 | 55.0 | 99.6 | 11.21 |
| 230 | 0.77 | 0.093 | 47.5 | 74.6 | 12.67 |
| 234 | 0.42 | .... | .... | 61.9 | .... |
| 236 | 0.27 | .... | .... | 54.4 | .... |
| 240.0 | 0 | .... | .... | 0 | .... |

TABLE X.—ETHYL ALCOHOL.

| $t$°C. | $r$. | $-dr/dT$. | $E$. | $\lambda$ | $10^4E/T\lambda$ |
|---|---|---|---|---|---|
| 20 | 22.03 | .... | .... | 208.0 | .... |
| 40 | 20.20 | 0.0873 | 47.5 | 205.3 | 7.39 |
| 60 | 18.43 | 0.091 | 48.7 | 199.2 | 7.35 |
| 80 | 16.61 | 0.0943 | 49.9 | 191.6 | 7.38 |
| 90 | 15.63 | 0.096 | 50.5 | 186.6 | 7.45 |
| 100 | 14.67 | 0.098 | 51.2 | 181.8 | 7.55 |
| 110 | 13.69 | 0.0995 | 51.8 | 174.9 | 7.73 |

| | | | | | |
|---|---|---|---|---|---|
| 120 | 12.68 | 0.1015 | 52.6 | 168.8 | 7.92 |
| 130 | 11.63 | 0.103 | 53.1 | 162.1 | 8.14 |
| 140 | 10.59 | 0.105 | 53.9 | 155.7 | 8.39 |
| 150 | 9.52 | 0.107 | 54.8 | 149.3 | 8.67 |
| 160 | 8.45 | 0.1085 | 55.4 | 141.7 | 9.03 |
| 170 | 7.34 | 0.1105 | 56.3 | 133.6 | 9.51 |
| 180 | 6.23 | 0.112 | 57.0 | 124.9 | 10.1 |
| 190 | 5.13 | 0.112 | 57.0 | 114.8 | 10.7 |
| 200 | 3.99 | 0.1105 | 50.7 | 104.0 | 11.5 |
| 210 | 2.91 | 0.1065 | 54.3 | 91.8 | 12.3 |
| 220 | 1.87 | 0.100 | 51.2 | 78.3 | 13.3 |
| 230 | 0.91 | 0.089 | 45.7 | 62.5 | 14.5 |
| 234 | 0.59 | 0.082 | .... | .... | .... |
| 236 | 0.43 | 0.077 | .... | .... | .... |
| 240 | 0.15 | .... | .... | 35.6 | .... |
| 243.1 | 0 | .... | .... | 0 | .... |

shown that the true heat of vaporization, even in the immediate neighborhood of the critical temperature, can be very closely obtained by means of two equations, one proposed by Mills and the other by Dieterici. Values thus obtained, designated by Mills and Dieterici, respectively, are given in the tables for comparison, and the constant shown as calculated from them. But one conclusion is possible when the papers cited and the results shown have been studied: *The increase in the value of the constant near the critical temperature is not largely due to errors in the values of the heats of vaporization used.*

*Are then the surface tension measurements in error?* The surface tensions used were calculated by Ramsey and Shields from the rise of the liquid in a capillary tube by means of the formula

5. $$\gamma = \tfrac{1}{2}\, r.\, h.\, g.\, (d - D),$$

where $r$ is the radius of the tube, $h$ is the height to which the liquid is raised, $g$ is the gravitation constant, and $d$ and $D$ are the densities of the liquid and its saturated vapor at the temperature of the experiment. Since errors in $r$ and $g$ could not thus affect the result, we have only to consider the probable size of the errors in $h$ and in $d—D$. There seems no good reason to suppose that large and regular errors were made in the determinations of the height of the rise of the liquid in the capillary tube. Regarding the possibility of errors in $d—D$, it is clear that, since $d$ approaches

$D$ in value as the critical temperature is approached, errors of measurement of the densities will be greatly multiplied near the critical temperature in their effect upon $\gamma$. But the well-known form of the density curves and the law of "rectilinear diameters" aids greatly in smoothing out individual errors of observation. The papers of Ramsey and Shields do not state from what source the densities were obtained, but comparison makes it fairly certain that the measurements of ethyl oxide and water (except the densities for these two substances of the liquid to 100°), methyl and ethyl alcohols, and acetic acid were by Ramsey and Young; for methyl formate and ethyl acetate by Young and Thomas; for benzene, chlorobenzene, and carbon tetrachloride by Young. The measurements of these investigators, as is well known, are exceedingly accurate and would introduce only comparatively small errors in $\gamma$. (We would note a misprint in the density of methyl formate, liquid at 140°, 0.7368 for 0.7638; also in accordance with Young's data, carbon tetrachloride vapor at 230° should be 0.1232; benzene at 280° should be 0.1660; and ethyl alcohol at °200 should be 0.1660; and ethyl alcohol at 200° should be 0.5568 for the liquid. The values for acetic acid have been revised by Young, the only changes of significance for our purpose being at 280° where the density of the liquid should be 0.6629 and of the vapor 0.0883; and at 320° for the vapor, which should be 0.2421. These changes will not affect the character of the results shown in the tables.) We conclude therefore *that the surface tension movements are fairly accurate and cannot directly cause the variation shown in the constant.*

*A relatively very large error is introduced in the determination of* $dr/dT$. For near the critical temperature—$T\,d\gamma/dT$ becomes very large compared to $\gamma$ and errors in $d\gamma/dT$ affect the constant almost proportionately. In determining $d\gamma/dT$ we deal with the difference of measurements of $\gamma$ in themselves nearly equal and subject to some individual error. We would be inclined to think that with any one substance the error introduced into the constant through the uncertainty of the factor $d\gamma/dT$ might be quite sufficient to explain the rise in the value of the constant at the critical temperature. But there seems no reason to suppose that the error thus introduced would always be large and in the same direction, unless there is some undiscovered defect in the determination of the surface tension. Nor is it reasonable to suppose that the consistently recurring decrease, even though it be small, in the value of the constant at low temperature, is to be attributed to chance errors in the measurements.

The authors therefore conclude *that the variation of the constant in the relation, $E/T\lambda$ = constant, proposed by Whittaker, is not due to the measurements used in testing the relation, but to the fact that the relation is only approximately true.*

With regard to the associated liquids, as was to be expected, the constant makes no pretense of constancy for the alcohols. But contrary to expectation, the constant remains as near a constant for water and acetic acid as it does for the non-associated liquids. We have no idea of the reason for this behavior.

It is seldom that any physical relation holds exactly true throughout a wide range of temperature. It is therefore quite reasonable to study the further relation stated by Whittaker and to seek a possible cause for the same. One of the authors in a paper already cited has discussed theoretically, and carefully tested by means of the extensive series of exact measurements available, the three following equations for the internal heat of vaporization:

2. $$\lambda = \left(T\frac{dP}{dT} - P\right)(V - v) = 0.0_4 3183 \left(T\frac{dP}{dT} - P\right)(V - v) \text{ calories.}$$

6. $$\lambda = \mathring{u}\left(\sqrt[3]{d} - \sqrt[3]{D}\right) \text{ calories.}$$

7. $$\lambda = CRT\, ln\frac{d}{D} = 4.77\, C\frac{T}{m}\log\frac{d}{D} \text{ calories}$$

Equation 2 is the thermodynamical equation already mentioned. In obtaining the constant the pressure is expressed in millimeters of mercury, and $v$ and $V$ are the volumes occupied by a gram of the liquid and of its saturated vapor.

In equation 6 $\mathring{u}$ is a constant for any particular non-associated liquid, $d$ is the density of the liquid, and $D$ is the density of the saturated vapor. The values of $\mathring{u}$ for the substances studied in this paper are given in Table XI. The equation was deduced theoretically by Mills from assumptions regarding the molecular attraction and has been extensively studied[1] and would seem to be exactly true for normal non-associated liquids.

In equation 7 $C$ is a constant for any particular substance, having approximately the same value, 1.755, for all normal non-associated liquids, $R$ is the usual gas constant, and $d$ and $D$ represent densities as before. The values for $C$ are given in Table XI. The equation was first proposed as an empirical equation by Dieterici[2] and has been further studied by Richter[3] and by Mills.[4]

Inserting the values of $E$ and $\lambda$ from equations 1 and 2 in equation 3, we get

$$8. \qquad \frac{\gamma - T\dfrac{d\gamma}{dT}}{T\left(T\dfrac{dP}{dT} - P\right)(V - v)} = \text{constant},$$

as the form of the relation already studied. Now if it were possible to get the limit of this equation at the critical temperature a further test of its truth could be applied. This does not seem possible with our present knowledge. $r$ probably falls out and $T$ cancels, leaving

$$\frac{d\gamma}{dT} \Big/ \left(T\frac{dP}{dT} - P\right)(V - v)$$

as the indigestible form of the equation. The combination of the equations 1, 2 and 3 under approximations has been studied by Kleeman in the papers cited.

Next combining the relation given in equation 6 with that of Whittaker we obtain, calling the constant of Whittaker's relation $k$,

$$9. \qquad E = ku'T(\sqrt[3]{d} - \sqrt[3]{D})$$

[1] *J. Phys. Chem.*, **6**, 209 (1902); **8**, 383 (1904); **8**, 593 (1904); **9**, 402 (1905); **10**, 1 (1906); **11**, 132 (1907); **11**, 594 (1907); **13**, 512 (1909). THIS JOURNAL, **31**, 1099 (1909).

[2] *Ann. Physik*, **12**, 144 (1903).

[3] "Ueber die innerer Verdampfungswarme, Rostock, 1908.

[4] THIS JOURNAL, **31**, 1099 (1903).

The values of $ku'$ are given in Table XII, though we have as yet been able to draw no conclusion from their product. That the surface energy of a liquid should be proportional to the product of the absolute temperature and the difference of the cube roots of the densities of the liquid and vapor is very suggestive. For it has been shown in the papers by Mills already cited that equation 6 expresses a relation between the molecular attractive forces, and that this relation leads to the conclusion that $u \sqrt[3]{d}$ is the energy necessary to overcome the molecular attraction in pulling the molecules of a liquid apart to an infinite distance. Simularly $u' \sqrt[3]{D}$ would represent the energy necessary to pull apart the molecules of a vapor to an infinite distance, the temperature of the vapor remaining constant. Now the so-called liquid surface is really the resultant of two surface layers, the one of the liquid and the other of its vapor, in contact, with oppositely directed forces. Hence it would seem that the total surface energy of a liquid, as usually so-called, can be divided into two parts, one part due to the liquid $E_L$ and the other part due to the vapor over the liquid $E_V$, the resultant forces being oppositely directed and the surface energy of opposite sign from the standpoint of a surface molecule. We can then write the equations:

10. $$E_L = KT\sqrt[3]{d}$$

11. $$E_V = K'T\sqrt[3]{D}.$$

12. $$E_L - E_V = E = K'T(\sqrt[3]{d} - \sqrt[3]{D}).$$

Perhaps equations 10, 11, and 12 do not express a point of view entirely new so much as they serve merely to add emphasis and to give quantitative expression to a fact already well known,[1] namely, that the nature of the surrounding gas influences the surface tension. It would seem from the suggested equations that perhaps the amount of such influence has been greatly underestimated.

It would seem probable that if equations 10, 11 and 12 are true, the surface tension as usually measured should similarly be capable of division into two parts, one part due to the liquid surface, the other part due to the gaseous surface over the liquid.

[1] See paper by Ramsey and Shields already cited, page 666, and similar determinations by others.

Such a process of division might result in finding simpler and more accurate relations between the surface tension and other quantities. Search by one of us for the proper modification to be applied to the liquid surface tension as usually measured in order to eliminate the effect of the vapor has apparently met with success, and if a full investigation confirms the results already derived the investigation will shortly be published.

TABLE XI.

| | Molecular weight | | $10^4E/T\lambda$. | | | |
|---|---|---|---|---|---|---|
| | $m$. | $u'$. | $C$. | $10^4k$. | $10^4u'k$. | $10^4Ck$. |
| Ethyl oxide....... ... | 74.08 | 103.76 | 1.724 | 20.56 | 2132 | 3544 |
| Carbon tetrachloride.. | 153.8 | 44.01 | 1.667 | 38.00 | 1672 | 6335 |
| Benzene.............. | 78.05 | 109.26 | 1.690 | 19.22 | 2122 | 3282 |
| Chlorobenzene....... | 112.49 | 81.66 | 1.714 | 21.19 | 1730 | 3631 |
| Methyl formate...... | 60.032 | 119.86 | 1.706 | 21.44 | 2570 | 3657 |
| Ethyl acetate........ | 88.064 | 98.88 | 1.812 | 20.61 | 2038 | 3735 |
| Water............... | 18.016 | 555.1* | .... | 6.85 | 3802 | .... |
| Acetic acid.......... | 60.032 | .... | .... | 14.74 | .... | .... |
| Methyl alcohol....... | 32.032 | 305.0* | .... | 5.88* | 1794 | .... |
| Ethyl alcohol........ | 46.048 | 240.9* | .... | 7.42* | 1787 | .... |

* Not constant.

If the value of $\lambda$ from equation 7 be used in the equation 3 proposed by Whittaker we have

13. $$E = kCRT^2 ln\frac{d}{D}.$$

The value of the product $10^4Ck$ is given in Table XI, but we can draw no conclusion of interest from the result. Equation 7, as has been shown in the papers cited, is not exactly true at very low vapor pressures for the liquid, but the error is probably not so great as one calorie for any of the non-associated substances over the entire range of temperature covered by the present investigation. The errors introduced by equation 7 are therefore far less than the errors of equation 2 with which it was combined.

Equation 13 is similar to equation 9 in its suggestion of a division of the total surface energy into two parts, one due to the liquid and the other due to the vapor. The resulting equations can be written,

14. $$E_L = K''RT^2 \ln d,$$

15. $$E_V = K''RT^2 \ln D,$$

16. $$E_L - E_V = E = K''RT^2 \ln \frac{d}{D},$$

where $K'' = Ck$. These relations will also be further studied.

In conclusion, we differ from the arguments and conclusions advanced in the papers by Kleeman already cited at many points, but we would call particular attention to but two things: *First.*—In the investigation of the *inverse fifth power* law of the molecular attraction[1] he uses data from the papers already cited on molecular attraction by Mills. He ignores the fact that in those papers it has been shown that the assumption of the *inverse square* law of the distance gives a consistent agreement with the data over the entire range of temperature, not only for the substances that he investigates but for numerous others. Also when the results within 20° of the critical temperature are left out of consideration Kleeman obtains a consistent decrease of about 25 per cent. in his results at different temperatures. If the attractive force did not vary with the temperature, the greatest allowable variation from the mean to be attributed to the usual errors in the data should be 2 per cent., and we have shown that the *inverse square law* gives results within this limit—and usually far within this limit—for eight substances investigated gave no divergence from the mean greater than 1 per cent.

*Second.*—To explain the variation he obtains, Kleeman thinks that the force of attraction may diminish with rise of temperature. The papers by Mills as cited find that as regards the molecular attraction all of the evidence disproves this position, and as regards the chemical attraction, the possibility of a change of attraction with temperature was further especially considered in a paper on chemical energy,[1] and no evidence whatever for such a belief was found in the case investigated.

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[1] *Phil. Mag.*, **19**, 795 (1910).

**Summary**

1. The relation proposed by Whittaker that "The surface energy of a liquid in contact with its own vapor at a temperature is proportionate to the product of the internal latent heat and the (absolute) temperature" has been investigated and the conclusion drawn that the relation is only approximately true.

2. The relation is shown to suggest a division of the so-called surface energy of a liquid into two parts, one part due to the liquid surface and the other to the surface of the vapor over the liquid. Further investigation of this suggestion is promised.

[1] *Trans. Am. Electrochem. Soc.*, **14**, 35 (1908).

CHAPEL HILL, N. C.

# THE RATE OF EXTRACTION OF PLANT FOOD CONSTITUENTS FROM THE PHOSPHATES OF CALCIUM AND FROM A LOAM SOIL*

BY JAMES M. BELL.

In a recent paper[1] entitled "Ein Beitrag zur Düngemittel und Bodenanalyse," E. A. Mitscherlich, R. Kunze, K. Celichowski, and E. Merres, have investigated the rate of solution of two phosphates of calcium and the rate of extraction of lime from a loam soil, by water saturated with carbon dioxide. The conclusion was reached that the usual equation expressing the rate of solution does not accord with their data. In this equation, *viz.*:

$$dy/dt = k(A - y) \qquad (1)$$

which when integrated becomes

$$\log (A - y) = \log A - kt \qquad (2)$$

A represents the concentration of the solution when final equilibrium is reached. In applying these equations, however, the authors have mistaken the significance of A; since the value of A used by them was the total quantity of the salt which was originally mixed with the carbonated water, and not that portion of salt which the liquid was capable of dissolving. Only when the quantity of salt added to the water is just sufficient for saturation is the above procedure valid. Since in the experiments, two different original ratios of dicalcium phosphate to water were employed, *viz.*: 1 : 750 and 1 : 1500, at least in one case (and probably in both) a wrong value was assigned to A. In the case

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[1] *Landw. Jahrb.*, 39, 299 (1910).

of tricalcium phosphate four different ratios of salt to water were employed. *viz.*: 1 : 1500, 1 : 2000, 1 : 3000, and 1 : 6000. So that in three of the four series, and probably also in the fourth, incorrect values were assigned to A.

As the above equations under these conditions failed to accord well with the data, a modified form of equation (2) has been proposed by the above authors,

$$\log (A - y) = A - ct^n \text{ ..................... } (3)$$

in which A represents the total quantity of the salt and $c$ and $n$ are constants. It seems to me proper, therefore, to recalculate the results, in order to determine whether equations (1) and (2) are really out of accord with the data.

Before discussing the recalculated results, several features of solution phenomena should be recalled. It is obvious that the rate of solution of any substance depends upon its exposed surface. Where the substance is in grains of widely different sizes, it is not possible to deduce any *rational* equation representing the rate of solution of such an aggregation of particles. And further, if any *empirical* equation is found to conform with the data for material in one mechanical condition, that equation will not, in general, describe the rate of solution of material which is chemically the same but mechanically different. Consequently experiments on rate of solution have usually been carried out with large crystals of low solubility, the surface changing but slightly during the course of the experiment. It is apparent also that an aggregation of crystals of uniform size and of low solubility may be considered as of constant surface during the solution.

In the experiments of Mitscherlich, Kunze, Celichowski, and Merres powdered material was probably used, but no statement is made as to its mechanical condition. The data indicate that the surface exposed must have altered considerably, for in the experiments with dicalcium phosphate over half of the phosphoric anhydride was extracted, and in the experiments with tricalcium phosphate, at least 45 per cent of the phosphoric anhydride was extracted. Consequently, even if the proper value of A (the total quantity of phosphoric anhydride in solution at equilibrium) had been used in the calculations, the usual equation for rate of solution might have failed because of the great changes in the extent of surface.

In the tables the first figures give the concentration of the solution one hour after the salt and water were mixed. In my recalculated results, this has been taken as the starting point of the reaction, for the following reasons: In every case more phosphoric anhydride passed into solution within the first hour (within which no determinations were made) than in the remaining time of the reaction (23–47 hours). Thus, calculated on the basis of 45.55 per cent. phosphoric anhydride in dicalcium phosphate, in one case the increase was from 20.16 per cent. after 1 hour to only 23.03 per cent. after 47 hours more, and in the other case the variation was between 35.09 per cent. and 39.67 per cent. Similarly for tricalcium phosphate with 43.22 per cent. phosphoric anhydride, the increases for four experiments were as follows: From 14.92 per cent. after 1 hour to 19.83 per cent. after 47 hours more; from 17.24 per cent. after 1 hour to 24.69 per cent. after 24 hours; from 20.99 per cent. after 1 hour to 34.55 per cent. after 48 hours; and from 21.46 per cent. after 1 hour to 42.14 per cent. after 24 hours. Thus, for most of the cases, the solution has been very close to equilibrium, and the extent of surface has probably changed but little. For the last two cases given (Tables V and VI) however, the changes in surface have been considerable. In the recalculated results this surface factor has been assumed constant, a legitimate assumption in all but two cases (Tables V and VI). Even in these two cases, in spite of this objection to the application of the usual equation, it will be seen that the equation describes the facts at least as well as the empirical equation proposed by the above authors.

TABLE I.—RATE OF SOLUTION OF DICALCIUM PHOSPHATE IN WATER SATURATED WITH $CO_2$. RATIO OF SALT TO WATER, 1 : 750. TEMP. 30° C.

| Original. | | | Recalculated. | | | |
|---|---|---|---|---|---|---|
| $t$. | $y$ found. | $y$ calc. from eqn. (4). | T= $t$—1 | Y= $y$—20.16 | Y calc. from eqn. (5) | $y$ calc.= Y+20.16. |
| 1 | 20.16 | 20.05 | 0 | 0 | 0 | 20.16 |
| 2 | 20.80 | 20.56 | 1 | 0.64 | 0.23 | 20.39 |
| 4 | 21.15 | 21.10 | 3 | 0.99 | 0.64 | 20.80 |
| 8 | 22.42 | 21.63 | 7 | 1.26 | 1.29 | 21.45 |
| 12 | 21.53 | 21.94 | 11 | 1.37 | 1.76 | 21.92 |
| 24 | 22.78 | 22.47 | 23 | 2.62 | 2.53 | 22.69 |
| 48 | 23.03 | 23.02 | 47 | 2.87 | 2.93 | 23.09 |

$$\log (45.55-y) = 1.6585-0252 \sqrt[20]{t} \quad (4)$$

$$\log (300-Y) = \log 3.00-0.035T \quad (5)$$

TABLE II.—RATE OF SOLUTION OF DICALCIUM PHOSPHATE IN WATER SATURATED WITH $CO_2$. RATIO OF SALT TO WATER, 1 : 1500. TEMP. 30°C.

| Original. | | | Recalculated. | | | |
|---|---|---|---|---|---|---|
| $t$. | $y$ found. | $y$ calc. from eqn. (6). | T = $t$—1. | Y = $y$—35.09 | Y calc. from eqn. (7) | $y$ calc. Y + 35.09 |
| 1 | 35.09 | 35.00 | 0 | 0 | 0 | 35.09 |
| 2 | 35.82 | 36.05 | 1 | 0.73 | 0.68 | 35.77 |
| 4 | 37.09 | 37.06 | 3 | 2.00 | 1.76 | 36.85 |
| 8 | 38.29 | 38.02 | 7 | 3.20 | 3.11 | 38.20 |
| 12 | 38.67 | 38.56 | 11 | 3.58 | 3.82 | 38.91 |
| 24 | 39.31 | 39.45 | 23 | 4.22 | 4.49 | 39.58 |
| 48 | 39.67 | 40.21 | 47 | 4.58 | 4.60 | 39.69 |

$$\log (45.55-y) = 1.6585-0635 \sqrt{t} \quad (6)$$

$$\log (4.60-Y) = \log 4.60-0.70T \quad (7)$$

TABLE III.—RATE OF SOLUTION OF TRICALCIUM PHOSPHATE IN WATER SATURATED WITH $CO_2$. RATIO OF SALT TO WATER, 1 : 1500. TEMP. 30°C.

| Original. | | | Recalculated. | | | |
|---|---|---|---|---|---|---|
| $t$. | $y$ found. | $y$ calc. from eqn. (8). | T = $t$—1. | Y = $y$—14.92. | Y calc. from eqn. (9). | $y$ calc. = Y+14.92. |
| 1 | 14.92 | 17.29 | 0 | 0 | 0 | 14.92 |
| 2 | 16.31 | 17.78 | 1 | 1.39 | 1.03 | 15.95 |
| 4 | 18.15 | 18.23 | 3 | 3.23 | 2.49 | 17.41 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 8 | 18.92 | 18.71 | 7 | 4.00 | 4.00 | 18.92 |
| 12 | 18.96 | 18.99 | 11 | 4.04 | 4.60 | 19.52 |
| 18 | 19.05 | 19.27 | 17 | 4.13 | 4.90 | 19.82 |
| 24 | 19.68 | 19.48 | 23 | 4.76 | 4.97 | 19.89 |
| 48 | 19.83 | 19.97 | 47 | 4.91 | 5.00 | 19.92 |

$\log (43.22-y) = 1{,}6357-0.222 \sqrt[20]{t}$ .......................... (8)

$\log (5.00-Y) = \log 5.00-0.100\, T$ .......................... (9)

Table IV.—Rate of Solution of Tricalcium Phosphate in Water Saturated with $CO_2$. Ratio of Salt to Water, 1 : 2000. Temp. 30° C.

| Original. | | | Recalculated. | | | |
|---|---|---|---|---|---|---|
| *t.* | *y* found. | *y* calc. from eqn. (10. | T = *t*—1. | *v*= *y*—17.24. | Y calc. from eqn. (11). | *y* calc. = Y+17.24. |
| 1 | 17.24 | 21.51 | 0 | 0 | 0 | 19.43 |
| 2 | 20.19 | 22.20 | 1 | 2.95 | 2.19 | 19.43 |
| 4 | 20.75 | 22.92 | 3 | 5.51 | 4.84 | 22.08 |
| 8 | 23.68 | 23.59 | 7 | 6.44 | 6.83 | 24.07 |
| 12 | 23.90 | 24.04 | 11 | 6.66 | 7.33 | 24.57 |
| 24 | 24.69 | 24.77 | 23 | 7.45 | 7.50 | 24.74 |

$\log (43.22-y)=1.6357-0.299 \sqrt[15]{t}$ .......................... (10)

$\log (7.50-Y) = \log 7.50-0.150T$ .......................... (11)

Table V.—Rate of Solution of Tricalcium Phosphate in Water Saturated with $CO_2$. Ratio of Salt to Water, 1 : 3000. Temp. 30° C.

| Original. | | | Recalculated. | | | |
|---|---|---|---|---|---|---|
| *t.* | *y* found | *y* calc. from eqn. (12) | T = *t*—1 | Y = *y*—20.99 | Y calc. from eqn. (13) | *y* calc. = Y+20.99 |
| 1 | 20.99 | 24.78 | 0 | 0 | 0 | 20.99 |
| 2 | 24.35 | 26.60 | 1 | 3.36 | 3.19 | 24.18 |
| 4 | 28.55 | 28.44 | 3 | 7.56 | 5.60 | 26.59 |
| 8 | 30.66 | 30.28 | 7 | 9.67 | 9.67 | 30.56 |
| 12 | 31.30 | 31.34 | 11 | 10.31 | 11.46 | 32.45 |
| 24 | 33.71 | 33.06 | 23 | 12.72 | 13.01 | 34.00 |
| 48 | 34.15 | 34.70 | 47 | 13.16 | 13.20 | 34.19 |

$\log (43.22-y) = 1.6357-0370 \sqrt[6]{t}$ .......................... (12)

$\log (13.20-Y) = \log 13.20-0.080T$ .......................... (13)

TABLE VI.—RATE OF SOLUTION OF TRICALCIUM PHOSPHATE IN WATER SATURATED WITH $CO_2$. RATIO OF SALT TO WATER, 1 : 6000. TEMP. 30° C.

| Original. | | | Recalculated. | | | |
|---|---|---|---|---|---|---|
| $t$. | $y$ found | $y$ calc. from eqn. (14) | T= $t$—1 | Y= $y$—21.48 | Y calc. from eqn. (15) | $y$ calc. = Y+21.48. |
| 1 | 21.48 | 28.31 | 0 | 0 | 0 | 21.48 |
| 2 | 30.30 | 32.59 | 1 | 8.82 | 6.40 | 27.88 |
| 4 | 36.71 | 36.44 | 3 | 15.23 | 13.85 | 35.33 |
| 8 | 39.67 | 39.48 | 7 | 18.19 | 19.13 | 40.61 |
| 12 | 40.88 | 40.77 | 11 | 19.40 | 20.34 | 41.82 |
| 24 | 42.14 | 42.22 | 23 | 20.66 | 20.70 | 42.18 |

$$\log(43.22-y) = 1.6357-0.462\sqrt[5]{t^2} \qquad (14)$$
$$\log(20.70-Y) = \log 20.70-0.160T \qquad (15)$$

TABLE XXI.—RATE OF SOLUTION OF LIME FROM A LOAM SOIL BY WATER SATURATED WITH $CO_2$. RATIO OF SOIL TO WATER, 1 : 10. TEMP. 30° C.

| Original. | | | Recalculated. | | | |
|---|---|---|---|---|---|---|
| $t$. | $y$ found. | $y$ calc. from eqn. (16) | T= $t$—2 | Y= $y$—0.1087 | Y calc. from eqn. (17) | $y$ calc.= Y+0.1087 |
| 2 | 0.1087 | 0.1069 | 0 | 0 | 0 | 0.1087 |
| 4 | 0.1199 | 0.1232 | 2 | 0.0112 | 0.0107 | 0.1194 |
| 8 | 0.1342 | 0.1378 | 6 | 0.0257 | 0.0264 | 0.1351 |
| 11.5 | 0.1461 | 0.1450 | 9.5 | 0.0374 | 0.0360 | 0.1447 |
| 16 | 0.1520 | 0.1511 | 14 | 0.0433 | 0.0436 | 0.1523 |
| 24 | 0.1572 | 0.1578 | 22 | 0.0485 | 0.0512 | 0.1599 |
| 32 | 0.1631 | 0.1620 | 30 | 0.0544 | 0.0544 | 0.1631 |

$$\log(0.18-y) = (0.2553-1)-0.315\sqrt{t} \qquad (16)$$
$$\log(0.057-Y) = \log 0.057-0.045T \qquad (17)$$

From the above tables it is evident that the results calculated by the usual velocity equation are in as good accord with the observed values, as are the results calculated by the empirical equation (3) proposed by the above authors.

Finally it should be observed that A, which is the maximum quantity of phosphoric anhydride which the liquid can extract, is not identical in Tables II, or in Tables III to VI. If the phenomenon being measured was one of solution only, this would of course, be a legitimate objection to these calculations. But it has been shown that when water acts on dicalcium phosphate or tricalcium phosphate a decomposition results, the solution having a higher ratio, $P_2O_5$:CaO, than the remaining solid.[1] The same sort of hydrolysis undoubtedly takes place when carbonated water is used as a solvent. With an hydrolysis whose extent depends on the original ratio of salt to water, the quantity of phosphoric anhydride in solution at equilibrium depends on the quantity of salt originally employed, and hence A will vary with the conditions of experiments.

In this paper it has been shown that notwithstanding the conditions militating against the use of the ordinary equation for rate of solution, *viz.*: the variable extent of surface and the fact that the phenomenon observed is not one of solution only but also of hydrolysis, this equation describes the data at least as well as the empirical equation proposed by Mitscherlich, Kunze, Celichowski, and Merres.

The usual equation for rate of solution also describes very well the extraction of lime from a loam soil by carbonated water.

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[1] Cameron and Bell, *Bull.* 41, Bureau of Soils, U. S. Dept. Agr.

# TOPOGRAPHY OF FAYETTEVILLE, NORTH CAROLINA

By William H. Fry.

The region directly around and in Fayetteville, N. C., in a general way can be divided into three subdivisions, each of which is topographically independent and distinct from the other two, although not so geologically. The first of these subdivisions lies to the west of the town and includes Haymount, Massey's, and Harrington's hills. These hills, despite their different names, are in reality all one, they being merely different portions of the range running northeast and southwest through the State. In fact, the line where one begins and the other ends is not a definitely settled point. The names are simply broad designations of the particular parts of the hills to which the major streets of the town run.

The second division borders the foot of this line of hills, and and extends in breadth eastwardly somewhat slightly above a mile. Here its border is marked by a steep but short incline which runs parallel, with but few breaks, to the hills, the opposite border. How far beyond the immediate vicinity of Fayetteville this may be true cannot well be ascertained, owing to the fact that plowing and erosion have rendered the incline indeterminable wherever the earth has not been protected by vegetation. But, judging from analogy, it should run parallel to the hills through the whole breadth of the State. This second division includes the upper and central portions of the town.

Bordering upon the second division and running indefinitely eastward is the third division. It may include the whole eastward section of the State; but detailed maps are too few to settle this point. With but little error it may be said that this third division takes its beginning at Dick, Green, Ramsey and North streets and includes in Fayetteville, what is locally known as Frogtown and Campbelltown, ending, as far as our present purpose goes, at the Cape Fear River.

From the foregoing description it can be seen that Fayetteville consists of three steps rising in a regular order of succession and each at an increasing height above the former. This condition is of course most easily seen on the streets running eastwardly and westwardly where the slopes have been protected from erosion by boards placed transverse to the streets, by layers of such resistant materials as cinders, and by the turfing of terraces in the lots on either side. Fortunately such streets are numerous. But even were this not so the line of demarcation would still be readily visible inside the town and even at some points outside where the land has not been cultivated. It may be remarked, by the way, that these topographical divisions correspond closely with the economic or political sections of the town, the lower or eastward section containing the most shiftless of the population, the middle division being the business section, and the upper or westward division being the residential district.

The upper or westward division, as has been stated above, is simply a part of the range of sand hills running through the State in a northeasterly and southwesterly direction. The part considered here is about four miles long, extending from the Cochran farm on the north to the Holt-Tolar-Hart Cotton Mill on the south. This section is composed essentially of white sand, mainly quartzose, overlain and in many places interstratified with a yel lowish red clay. All of the materials are rather coarse. Only in those parts where the yellowish red clay occurs is the soil cultivated. At the other places the sand is almost pure quartz, unadulterated save by a little vegetable mould. Practically all of the clay found on or near the roads has been transported to the spot for the purpose of making sand-clay roads.

The natural vegetation of the area affords a true and typical index of its sandy and desert character. Here are found pines, scattered and thin bunches of rough grass, and an abundance of the prickly pear cactus (*Opuntia*). The prickly pears are so abundant that small barefooted boys invariably keep to the roads or well beaten paths, games on anything but much used places being entirely out of the question.

This upper section or division can be called a topographical unit only if viewed in a very general way. But in reality it is made up of very marked hills and valleys. These are comparatively close together and seem to be scattered about promiscuously. The slopes of these, however, are all gradual, there being, with one exception to be noted later, no steep or abrupt inclinations. This condition is, of course, what might be expected in a range of hills of the character of this where the material readily yields to the action of both rain and wind.

Two main valleys cut through the hills and form the loci to which all the minor valleys tend. As usual in this area, these two valleys are very wide compared with their depth and have very gradual slopes both laterally and longitudinally. The bottoms and broad plains which are occasionally flooded after heavy rains. At one point, however, as noted above, near Monticello Heights, the slope is exceedingly abrupt. But this can be accounted for by the fact that here the stream has left the hills and is flowing along the foot of one of them with the swifter motion on the westward or hill-side of the stream, thus naturally tending to encroach upon the hill. Besides, the rapid erosion of the slope above the stream is prevented by a thick growth of tall pines and underbrush, which has, so far as could be learned, never been cut.

The second and third divisions have no distinctive character by which they can be separated from each other save position. As has already been said, they lie parallel both with each other and with the first division.

The material composing them is much finer in texture than that of the hills, being in many cases simply a mixture of clay and organic mould, which extends to a considerable depth, as would be observed in recent excavations made for a sewerage system. Much of the organic material was undoubtedly deposited when the land stood at a lower level and swamp conditions prevailed, before the uplift allowed the streams to cut deep enough to afford drainage for the area. The clay is probably derived from the wash of the hills. At a depth of about ten to fifteen feet below the surface sand and gravel are encountered. This is pure enough to be used for plastering after having been screened from the gravel that occurs with it. The gravels are very much rounded, indicating much exposure to running water.

As for the origin of this topography: it is probable that the hills constitute the upper part of an old shore line from which the waters receded in a very recent geological period, the exact time not having been determined. The second division, as indicated by the water-worn sand and gravel, was probably that part of the shore between high and low tides. The clay and organic matter were probably deposited after the emergence of the division. The third division, which now slopes gradually eastward, was probably covered by the sea. These explanations account for the present rather unusually regular topography; while later erosion and transportation of material account for all seeming irregularities such as are found at many places near the creeks.

As for geological changes now going on: in the hill region the sand is being cemented together by iron oxide, forming a coarse red sandstone. This is found in lumpy aggregates, or more often in thin, closely compacted layers or hardpans. Erosion, as has already been mentioned, forms broad, gently sloping valleys in the hills; but in the lower regions, where the first ten or fifteen feet is clayey, narrow and deep valleys are cut reaching a depth of thirty or more feet, where the streams debouch into the river.

# GREAT DAMAGE FROM RECENT FOREST FIRES! WHAT SHALL WE DO ABOUT IT?*

During the latter part of March and the first half of April, eastern and central North Carolina have experienced one of the severest periods of dry weather that has occurred for many years. Not only did little or no rain fall over the greater part of the State for about five weeks, but there was almost continuous sunshine during this period. Grass and leaves in the woods became as dry as tinder, and forest fires were of almost daily occurrence over the greater part of the State.

The Survey, anticipating the usual spring drought, issued about the middle of March a statement to the newspapers, calling attention to the serious effects of such fires, in which it brought out the fact that the greater number of these fires—at least the most destructive ones—at this season are caused by farmers carelessly setting fire to brush, stumps, and other rubbish, collected in clearing up the ground for cultivation. This statement was published at length, or in shortened form, by many of the leading State newspapers and was very favorably noticed by the leading lumber journal of the country. Though this warning was timely, and probably exerted some influence, it did not have a very marked effect. So much damage was reported through the various State papers that the North Carolina Geological and Economic Survey determined to investigate the causes of these fires and see if the damage done by them was as great as the dispatches indicated, with tne purpose of working out some method of preventing the almost annual occurrence of these destructive spring fires.

About the middle of April the Forester to the Survey made a trip into Moore and Cumberland counties with the special purpose of collecting data on fire causes and damage. At this time

*Press Bulletin No. 39, N. C. Geological Survey.

the drought had been broken by a general rain and all the fires had been put out, though some stumps and logs were still smoking on some of the more recently burned areas. Conditions were found to be worse even than had been represented in the press. During the dry spell, scores of fires had started in these counties alone, many of them burning for days, traversing miles of country and covering thousands of acres of woodland. At least half of the area of the southern part of Moore County and by far the greater part of the woodland of Cumberland County was found to have been burnt over this past spring. Some areas had been burnt in the winter, and on these, though the mature growth showed little injury, the young growth was, of course, largely destroyed. In every direction blackened woods, scorched and dead pines, dying and dead hardwoods could be seen; even the resistant scrub oaks were absolutely killed on thousands of acres.

As is well known, fires are very much more destructive in the late spring than at any other season of the year. The sap being up in the trees and the new leaves coming out, make the trees especially susceptible to fire. On account of the excessive dryness the recent fires have been unusually severe, and, though the efforts to extinguish them seem to have been greater than usual, many fires had to practically burn themselves out because it was impossible to work near enough to the fires to stop them. In many cases fire was carried from 50 to 100 yards, or even more, through the air by the wind. So great was the heat and so rapid the spread of the fire, that in many cases a thousand acres, or more, burnt over in two or three hours time.

In these two counties, not less than 250,000 acres of woodland have been burnt over during the past winter and spring, and probably half of that amount was burnt during this last dry spell. The damage varied with the time at which the fire occurred, with the amount of dead vegetable matter on the ground, and with the age, density and character of the growth on the area. Though the greater part of the area burnt—probably 80 per cent—is sand-hill land, growing only small scrub oak and little or no pine, still the damage is very serious. As this land is used only to grow timber, the prevention of a profitable growth on it means destruction of the usefulness of the land. Fifty cents an acre is a low average for the damage done by one fire to this class of land. Near the towns, however, especially the towns that are chiefly dependent for their prosperity on the winter resort business, the injury by fire has been eight or ten times this amount. In many cases, attempts have been made, with more or less success for a number of years, to protect the pine growth, both for the value of the trees for timber and more especially for their aesthetic value. Where this was the case, the destruction of the young growth on these areas can hardly be estimated in dollars and cents. In several such cases the damage over considerable areas amounts to from five to seven dollars per acre, not including the destruction of buildings. To show that this is a conservative estimate and to illustrate in what way the amount of damage is arrived at, a specific estimate is here given. On a large tract of land near one of these resort towns, used, through the courtesy of the owner by the general public as a park and pleasure ground, about 900 acres was burned over early in April by two closely consecutive fires. Of this 900 acres, 50 acres was round timber, that is, mature, unboxed, long-leaf pine; 150 acres was old field growing up to young pine; the balance of 700 acres was boxed timber, or rather, scrub oak with scattered mature pines which had been previously boxed for turpentine. The round timber is worth approximately $50.00 per acre for the timber itself. It was estimated that one-tenth of this timber was killed; probably half of this can, however, be used for fire-wood. Thus, out of $5.00 worth of timber killed, half of it is a total loss, and the other half a partial loss, as the price for cord wood is less than for saw timber; this would make a total loss of $3.75 per acre. The loss to this part of the property in appearance is roughly estimated at fifty cents an acre, though a very much larger sum would not compensate for the loss to the beauty of this tract of forest. The estimated damage then is $4.25 per acre. The old field was covered with a growth of pine averaging approximately 18 years of age. This timber will be worth at least $50.00 per acre when 100 years old, so that one year's growth would be worth fifty cents an acre, or 18 years' growth would amount to $9.00 per acre. As, however, some of the growth was not killed outright, though all was severely injured, the damage to the young growth on this tract was estimated at $5.00 per acre. The young pine was growing in the most conspicuous part of the property, that surrounding the golf links, and the injury to scenic beauty was therefore much greater here than on any other part of the property. $2.00 per acre is a low estimate for this damage. This, together with the $5.00 for the destruction of the trees, makes a total loss of $7.00 per acre for this 150 acres of old field. On the area on which the boxed timber was the chief valuable growth the damage consists (1) in the burning down and consequent destruction of half the stand of boxed timber, amounting to some 250 feet board measure, per acre, worth approximately $1.25 per acre; (2) in the total destruction of a stand of seedlings and young growth of pine approximately four years old, worth $2.00 per acre; (3) in the injury to the beauty of the tract, fifty cents per acre, or a total of $3.75.

The above estimate does not include fences, bridges, etc., approximately $200 worth of which were destroyed. An enormous quantity also of lightwood was burned up, for which a nominal estimate of twenty-five cents per acre is made. This gives a total loss for the 900 acres burned over of something like $4,300, which would be increased by $100 to $200 for the cost of fighting these two and some other fires that threatened the property.

The above gives some idea how the loss through fire can be approximately arrived at, and also brings out the point that it is not only the loss of salable material that should be counted, but all other direct and indirect losses. Even in this estimate, however, one very important item has been omitted, which is the impoverishment of the soil from the destruction of the humus. This is very serious, and is very generally recognized, though it is exceedingly hard to put it into dollars and cents.

These two fires under consideration were set by sparks from a railroad train. So, also, was the one in Cumberland County, n which, after burning over several miles of country, an old woman lost her life. This woman, Mrs. Kate Howard, lived with her sister not far from a well traveled road. The two of them made their living, at least through the spring and summer, by gathering flowers and plants in the woods and shipping them North. The fire which this woman went out to fight was threatening not only her house but her livelihood, as wherever the fire went it destroyed the flowers, so that even had she not lost her life, the fire was a very serious thing to her.

Another very destructive fire in the loblolly pine country, near Fayetteville, was set out by a tenant farmer who owned no land of his own. This man set fire to half an acre of old field that he wanted to plow, in the middle of the day. The wind quickly carried the fire beyond control, and before it was stopped, two or three hours later, it had swept through 1,200 acres of woodland belonging to a dozen or more different men, causing an estimated loss in timber and fences of nearly $5,000.

Another destructive fire in Cumberland County was caused by setting fire to a brush pile on a dry, windy day. The fire was carried from this pile by the wind 75 or 100 feet across a wide road, setting fire to the woods and quickly doing a thousand dollars worth of damage to the fences and young timber of one of the neighbors.

Many people, when asked as to the cause of so many destructive fires, attributed them entirely to the unprecedented dry weather, forgetting that this alone could not cause the fires. Most people, however, seemed to recognize the fact that during such a drought the greatest care should be exercised to keep fires from getting out, and that it was to the neglect of proper precautions in handling fire that the greater part of this damage was due. This criminal neglect, chiefly on the part of the railroads and of the small tenant farmers, was brought out very clearly in the present investigation. Out of over thirty fires taken note of, practically one-half resulted from sparks from railroad locomotives, and about one-third were caused by fire getting away from farmers carelessly burning brush and rubbish. It seems to be generally felt that the only way such fires can be prevented is by the passage of a law for the purpose of controlling or restraining those responsible for these two classes of forest fires. The State Geological and Economic Survey is of the same opinion, and suggests that legislation along these lines be taken up next winter.

Railroad fires could in large part be prevented if the railway companies kept their rights-of-way cleared of brush, grass, weeds and other inflammable material. One substantial property owner in Cumberland County says he asked the railroad two or three times the past winter to clear off its right-of-way, apparently without result. Very few roads keep the whole of their right-of-way cleaned up, though some seem willing to coöperate with property owners by burning off each side of their track at some time during the winter. The railroads have in most instances been given their right-of-way by the property holders along the line, and they ought to be compelled by the State to keep it cleaned up, so that it does not become a menace to these adjacent owners. In many States this is required, and it is found to work well where the law is enforced.

Nearly half of the destructive fires occurring late in the season were found to be due to the careless burning of rubbish, brush, log piles, stumps, etc., by farmers clearing up their land for cultivation. In most cases it was found that it was not the owner of the land who was responsible for the fire, but some small tenant farmer who had little interest in the property, and, in most cases, had no land of his own. Even small fires, during the dry spring weather, will be carried quite long distances by the wind—instances of fire being carried 100 yards or more, across plowed land, were cited by several different people. It ought to be made a criminal offense for a man to set out fire, even on his own land, during such dry weather, for a man who has no property, and cannot pay a fine, cares little about being sued for damages. Intelligent citizens and property owners all over the State would, it is thought, support a law to this effect, and it seems the only way to prevent fires resulting from such criminal carelessness.

To both of these proposed remedies, a very strong and valid objection can be raised, namely, that the passage of laws is of little value unless they are enforced. Even now the law requiring notice to be given to adjacent land owners before a fire is set out is a dead letter, because it is never enforced. A man very naturally objects to suing a relative or a near neighbor and perhaps landing him in jail, for, besides the natural reluctance to make an enemy of one who is possibly a good friend, there is always present the idea that an offended neighbor may retaliate in some way at some future time. An instance of this reluctance to sue was brought to the attention of the Forester during this investigation. Two men had set fire to the woods during the recent dry spell, on purpose to prevent any possible fire getting to their fences. After securing their own property, they had made no attempt to extinguish the fire, and it had burned over a large extent of country, and done very serious damage to several of the neighbors. This was clearly in violation of the present law. Witnesses could have been procured to testify to the facts in this case, but no one would prosecute, because every one who was injured was related more or less to one or other of these men. This feeling has, all over the State, practically nullified the law, so that, where it is no one's duty to enforce the law, it becomes useless. It is therefore suggested that in addition to the two laws above outlined, the execution of them be placed in the hands of a man specially appointed in each county or township desiring it. This man, who might be termed a fire warden, should be appointed by the Governor, on the recommendation of the people of the county, and be given powers similar to those of a deputy sheriff. His duties should be to investigate all forest fires which occur in his county, to find out who the guilty parties are, and to report direct to some State official, such as the State Geologist or the State Forester. This official would then, through the fire warden on the ground, prosecute all offenders against the forest laws. Thus the idea would be eliminated that any such prosecutions were brought about from personal motives. It is not recommended that county fire wardens be appointed in every county in the State, but only in those in which the fire danger warrants it. In counties where there is over 50 per cent of woodland the costs for the maintenance of such an official would quickly be much more than offset by the increased value of the forests of the county through the prevention of fire. If such laws had been in effect, and such men had been on duty in Moore and Cumberland counties the past spring, there is no doubt that a saving of many thousands of dollars would have resulted to the people of these counties.

During the present summer, while members of the two branches of the State Legislature are being nominated and elected, the people should keep this question in mind. Every candidate should be interrogated as to how he stands on the forest fire question. It is really very much more important to determine what a man intends to *do* in the Legislature, than what he *thinks* on a question which does not affect this State at all. It is hoped that the next Legislature will take up this question and push through a law that will furnish the woodland owners of the State the protection that they require and demand.

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## GOOD ROADS AND CONSERVATION*

By Joseph Hyde Pratt.

*Mr. President and Members of the Southern Conservation Convention*:

I was very glad indeed to be invited to make an address at the Southern Conservation Convention, and especially so when it was suggested that I speak on the subject of Good Roads in their Relation to Conservation.

It will be necessary for me at times, perhaps, to drift considerably away from the actual subject, in order to make clear certain relations that I feel exist between good roads and conservation.

There is a very close relation between good roads and the successful carrying out of the principles of conservation; in fact, the construction of good roads is one phase of conservation. In the first place, conservation, as applied to our natural resources, means not only their preservation and conservation but means also that we will be able to utilize them perpetually. The problems relating to the conservation of these resources are not local but national and state questions; they are questions that affect and are of interest not only to the individual but to the whole people, and, therefore, in adopting measures looking toward the conservation of these natural resources, the nation must be considered before the state and the whole people before the individual. This does not mean necessarily that the Federal Government should control and dominate all policies relating to conservation; although, personally, I believe that this

*An address delivered before the Southern Conservation Convention, Atlanta, Ga., Oct. 8, 1910.



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would be the very best step that could be taken for the most successful accomplishment of all measures relating to conservation. It does mean, however, that the Federal Government should have at least some supervision in the carrying out of these policies so that what is done shall react to the good of all the states and not simply to the individual state and often to the disadvantage of adjoining states. There are so many questions coming up relating to conservation that cannot be applied to the individual state, and the accomplishment of the desired results can only be obtained when they are considered as interstate problems. To illustrate, you might take the question of the protection of forests from fires; one state may pass most rigid laws relating to the protection of its forests from fire and yet the adjoining state may give no protection at all to its forests, and forest fires, starting in this state, gather great headway so that it is almost impossible to prevent their crossing the imaginary state line and doing a great deal of destruction in the state which has rigid fire laws that are being enforced as far as that state itself is concerned. Such a condition can, and does, exist in the Southern Appalachian reign; and, unless all the states will take up the question of fire protection for their forests, there will always be more or less destruction of the forests near the borders of these states from fires that have originated in adjoining states.

Another illustration of the need of some Federal supervision is in the protection of mountain trout from destruction on account of sawdust that is thrown into many of our streams. Many of our mountain streams flow from one state to another and from one county to another and in many instances the counties within a state on the lower waters of a stream have passed rigid laws regarding the throwing of sawdust in these streams and yet the counties higher up on these streams have no such laws, and their lumbermen are allowed to throw sawdust in the streams, with the result that the counties lower down, who have the rigid laws against throwing sawdust into the streams, derive no benefit whatever from these laws as their streams are filled with sawdust from the counties above. This can also be true where the streams flow from one state to another; one state, on the lower waters of a stream, may have laws against throwing sawdust or other deleterious material into the stream, while the state which contains the upper waters of the streams may have no such laws whatever, and thus the first state looses all of the benefit that its good laws should give.

This is also true in regard to the conservation of water-powers. One state will pass laws for the conservation and protection of its waterpowers, and yet the sources of the streams are within another state which is doing nothing whatever to protect its water supply, and thus the waterpowers in the other state are largely decreased in power on account of the lack of protection in the state where the streams originate.

From the above it can readily be seen that there should be Federal supervision for carrying out the principles of conservation that are interstate in their benefits, and decidedly state supervision in connection with the conservation of the natural resources of the various counties composing the state.

Every state should be interested in the development of every other state, for no advancement can be made in any one without its being directly or indirectly a benefit to all the others.

We should carry the question of conservation further than its application to our natural resources and apply its principles to the preservation of the health of our people and the conservation of their labor, time, and wealth, and this latter view, it will be found, is fully as important as the first. We will find that good roads play perhaps a more important part in the carrying out of this latter phase of conservation than in the former.

Under the head of natural resources we would have: (1) Soils, (2) Forests, (3) Water-Powers, (4) Products of the sea.

The development, and even the life, of this nation is dependent upon these natural resources, and, while some of them are of less importance than others, yet the best and healthiest growth of the nation is dependent upon the conservation of all of them. When one stops to consider that the population of this country is now increasing at the rate of about one-fifth of its total population each ten years, one begins to realize how many more millions of people must be fed and clothed from the products of the soil. By the middle of the present century it is estimated that there will be about one-hundred and fifty million people in the United States. This increase is not confined to any one state or territory, but there is a decided and steady increase in all of them. This large growth in population means a constantly increasing call upon all our natural resources; and it is time that we, as a nation, give very serious consideration to their conservation, for we must realize that our responsibility does not rest with providing for the present generation, but we must also do our part toward providing for future generations by conserving and perpetuating for their use the natural resources that we ourselves now enjoy.

The conservation of our soils and forests stands out pre-eminently as the most vital duty demanded of us, and the carrying out of this to its fullest accomplishment falls principally upon the farmer. The farmer is called the most independent of men, and, in many sections of the country, he is; but in many others he is not, and instead we often find him a very discouraged citizen. If we expect our farmers to take an interest in the conservation of our soils and forests, we must assist them by providing adequate means of transportation for their products and prevent combinations from being formed whose object is to curtail the price received by the farmer for his products and increase the price to the consumer. Upon the farmer rests almost entirely the problem of the conservation of the soil, and his interest will increase in the ratio that we improve the social condition of farm or rural life, and it is in this connection that we will find that good roads play a very important part in improving their condition. Good roads will do more toward improving the social condition of rural life than any other agency that can be inaugurated. At the present time it is possible for the people of our rural sections to have many of the economic advantages and conveniences of the city,—such as hot and cold water in their houses, lighting and heating systems equal to any in the city, and telephone connections,—at little or no more cost than these same conveniences would cost in the city. Rural mail carriers now deliver mail to the citizens of our rural sections from once to twice a day. Yet with all these conveniences, which many of us now deem absolutely essential and necessary, the farmer, if his home is connected with that of his neighbor and with town by a bad road, is handicapped in his financial and social development, and these many conveniences that have improved his home life lose a great deal of their value in improving the social conditions of the community. It is surprising to note the wonderful uplifting effect that good roads have in a community that has been accustomed for generations to bad roads. It means that houses will be painted, fences will be repaired, flowers and shrubs planted in yards, and, in a number of instances where chicken coops and pig pens were in the front yard, they have been removed to a less unsightly place in the rear of the yard, and it is due to the fact that a good road has been constructed by that farm.

At the present time there is a great deal of thought being given to the problem of keeping the young people, especially the young men, on the farm. Personally, I believe that the construction of good roads throughout the farming sections of our country will do more than any other one thing to keep these young men on the farm. I do not wish to give the impression that I believe all young men who are raised in the country should remain there, for there are many young men raised on the farm who are specially equipped to become doctors, lawyers, ministers, engineers, and business men; yet, there are a great many others who will make much better success in life if they do remain in the country and take up farming as a profession. Many of these young men are now leaving the farms and going to our cities and towns, where they accept positions in stores and mills at low wages and with little prospect of ever bettering their condition to any great extent. These same young men could, in many instances, have made a splendid success at farming. It is not the work or life on a farm that many of them have objected to, but it has been the isolation of farm or country life. This can be remedied by the construction of good roads, and I am confident that any community or county in many of our Southern States that is now being troubled by its young people leaving the country, can check this exodus very materially if they will arrange for the construction of a system of good roads. It will be one of the very best investments that the community can make, for it will not only help to solve the problem under consideration, but it will also assist in solving the labor problem that is now confronting so many of our farmers.

Our farmers are also closely identified with our forest areas and we will find that there is a decided relation between good roads and the conservation of these forests. As has been stated by Mr. J. S. Holmes, Forester of the North Carolina Geological and Economic Survey, "a forest cannot be managed to the best advantage unless * the inferior species and lower grades of timber can be profitably marketed, and this is only possible where the cost of transportation is low enough to warrant it. The difference between $1.00 and $2.00 per ton for hauling, or the difference between a bad and a good road, will often determine the possibility of profit or loss in marketing timber".

In many of the counties of the Southern Appalachian region the cost of hauling the timber to market is greater than what the owner receives for the timber on the stump. As an illustration of the amount of money that is being expended for the transportation of lumber over our public roads, I will give some figures regarding the sixteen counties in North Carolina west of the Blue Ridge. In this region three-quarters of the area is now in forest, and, probably, the larger portion of this area is better adapted for the production of forest than for any other purpose. During the year 1909 it was estimated by the State Forester that fifteen million cubic feet of timber were hauled to market or to the railroad by wagon over the public roads of these counties. The

* Bull. 8. So. Appalachian Good Road Association, 1910, p. 13.

estimated cost of hauling this timber was $750,000 and in this particular instance it amounts to twice as much as the timber itself was worth on the stump. With this excessive cost of hauling, it can readily be seen that only the most desirable types of timber can be hauled and that the lower grades and the inferior species must be left in the woods. With these conditions, it is only natural that the lumberman should skin the forest of every single desirable tree that he can afford to cut and haul to market, and thus many of the forest areas of the Southern Appalachain region have been almost entirely depleted of many of their most valuable trees, such as black walnut, cherry, yellow poplar, and white oak. There is but little chance of decreasing the length of haul in transporting these forest products, but there is a splendid chance of increasing the load to be hauled by the construction of good roads.

Our farmers are partially at fault for the wholesale waste of our timber, but the states themselves are by far the most to blame for not providing good roads through these forest areas, which would have permitted the farmer to derive a good income from his farm and not be tempted to sell his timber for a mere song. Thus it will be seen that if the forests are to be protected and perpetuated, we must construct throughout the region a system of good roads. There is another way in which good roads throughout these forest areas will play an important part in the conservation of our timber resources, and that is, they will enable automobilists, coaching parties and tourists to travel through these forest areas, who will recognize the importance of these areas to their respective states and it will then be much easier to pass the laws necessary to conserve these forests.

The reclamation of cut-over and abandoned farm lands is much more readily accomplished when these areas are traversed by good roads. Although the farmer may not consider it a profitable investment to reforest his cut-over lands or that portion of his land which he has abandoned for farming purposes, yet he will take up the question of the reforestation of these areas if they are traversed by good roads, for he will realize that it will improve the general appearance of the country, making it look more profitable and so increase the value of his cultivated farm, by having it surrounded by land that is growing forests instead of land that is being cut into gulleys and looks like wornout, abandoned farm land. With a system of good roads it will be found that many of the farms that are not now being cultivated will be worked and again become prosperous, and thus add to the material wealth of the state in which they are located. It has been said by the Governor of New Hampshire, that since the construction of a system of good roads throughout that state during the past five years, nearly all of the abandoned farms in New Hampshire or at least the majority of them are now again in a state of cultivation. If this can be made true in one state it can be made just as true in another·

From the commercial standpoint the question of the construction of good roads comes closer home to the farmer than to any other class of people, as practically all agricultural products have to be hauled for at least some distance over the public roads, and such a system of roads will do more to conserve the time, labor, and wealth of the farmer than any other one thing. As we know, there is but little chance of reducing the railroad transportation charge on these products, but there is a splendid opportunity in nearly every county of every state in the South to reduce the public road transportation charge. Over many of the public roads of the South it is now impossible to haul a load of more than half a ton. It may be that a considerable portion of the road over which the load is to be hauled is a fairly good one over which one or two tons could easily be hauled, but, on account of the many heavy places and grades on this road, it is impossible to haul over the whole distance more than the half ton, as it is necessary to load the wagon for the rough, heavy places and not for the good portion of the road.

There are many ways in which the farmer will be benefited by a system of good roads besides improving his social condition, and it may be advisable to enumerate these here, as they have a direct bearing on the improvement in country life, which, in the end, has a direct bearing on conservation, especially in its relation to soils, and also in conserving the time, labor and health of the farmer. A system of good roads connecting farm with market will often permit the farmer to raise certain crops that are more valuable than others, more easily handled, and which will bring a much greater income than he could possibly raise and market where he is on a bad road. I could give numerous cases to illustrate this point, but it is sufficient to state here that it will be found that good roads are a factor in making a farmer realize the necessity of getting the most out of his soil, realize the necessity of studying his soils and the value of rotation of crops.

Another beneficial result that the farmer derives from good roads is that he is able to economize time and force in the transportation of produce between country and market. The distance that the farmer lives from market is not a question of miles, but of the roads that he must travel to reach the market, and of how many hours and how many horses it requires to haul a load to market. When thus measured, ten miles of good, smooth highway is not as long as a few miles of mud and stone. Our farmers are realizing more and more that the distance they live from market is measured in time and not in miles.

Another advantage that improved roads will give to a farmer is that it will permit him to take advantage of market fluctuations in buying and selling, and to take advantage of any special demand that may arise for any of his products. It will permit him to do his hauling at any time of the year regardless of the weather, and thus, when it is too wet to work his crops, he can haul to and fro from town. At the present time in many sections of the country the farmer can only haul to advantage in dry weather, and frequently the dry weather comes just at the time he most needs to work his crop; so that he either loses the opportunity of a demand that has arisen for certain of his products at a good price or has to neglect his crop. In many sections the construction of a system of good roads has made it possible for farmers living eight or ten miles from large communities to raise garden truck where formerly this could only be produced advantageously within a few miles of a city. The railroads are also greatly affected by the conditions of the public roads in regard to the transportation of farm products, for the reason that on account of bad roads many of our farmers are only able to raise certain crops and are only able to haul them at certain times of the year, which means congestion of freight at the railroads during certain seasons and from 50 to 75 per cent less during the rest of the year. I believe that these conditions in many sections of the country have a decided effect upon the freight rates that the railroads can give for hauling farm produce. Congested freight, which makes it necessary for the railroads to go to extra expense to produce cars with practically no freight at other times, when perhaps their cars are going by these stations empty, causes the extra high freight rates.

A third beneficial result that the farmer derives from good roads, and one regarding which most of our farmers have paid little, or no attention, is the saving in the wear and tear on horses, harness, and vehicles, when these are used over good roads as compared with their cost over poor roads. Then, again, little thought is given to how many days in the year we have to leave our horses and mules standing in the stables on account of bad roads. There is an enormous sum lost each year in this way by nearly every Southern State that can be charged up directly to bad roads. This amount is due to the wear and tear on harness and wagon and the loss of time of those whose living is dependent upon driving and teaming and the loss that a liveryman and farmer sustains when he is unable to work his animals on account of bad roads. This amount in many of the Southern States is from twelve to fifteen million dollars a year, all of which could be readily saved to the states by the construction of good roads.

It will be impossible to carry out the principles of conservation in their entirety until the people are more fully educated as to the need of conservation, and there is no better place to begin this educational work than in our public schools. Nature studies are already beginning to take a strong hold in many of the schools of some of the states and it will not be long before the general subject of our natural resources will be taken up in nearly all our public schools. The best results, however, along this line can only be accomplished in the better graded schools, and we will find that such schools are dependent upon good roads. Although the one room schoolhouse that dotted this country in its early history, has done a great deal of good in its day, yet, we all realize that a six room schoolhouse, with six teachers, can do better work than six schoolhouses of one room each, where the same teacher is obliged to teach scholars of all ages and attainments. The development of the graded school is dependent upon the construction of good roads, and, although we may not realize it, yet every mile of good road that we build we are increasing thereby the educational facilities of our children.

In closing, I wish to emphasize one point, and that is that while the construction of good roads is one phase of conservation, the maintenance of the road after it is once constructed is a still more important phase of conservation, and one regarding which we are often apt to give but little consideration. Any county or state arranging to construct good roads should always at the same time provide the revenue for the maintenance of the roads after they have once been constructed.

# COLLOIDAL CHEMISTRY*

By Duncan McRae

Although the first important work on colloidal chemistry was done in 1861, by Sir Thomas Graham, it is within the last few years that the most rapid advances in this field have been made. Since 1900 not only have a number of chemists been engaged in research on this subject, but the attention of chemists generally has been turned in this direction. This is shown in the number of reports and addresses that have been given on colloidal chemistry. In 1905 A. A. Noyes delivered, as his presidential address before the American Chemical Society, a paper on "Colloidal Mixtures", and in 1908 H. R. Proctor delivered an address on "Colloidal Chemistry" before the British Association for the Advancement of Science.

There have also been a number of German monographs published on the subject of colloids. The research work has been so abundant that nearly every abstract journal contains one or more articles on some phase of this subject. Now, there is a special journal devoted entirely to Colloidal Chemistry, edited by Wo. Ostwald: Zeitschrift fur Chemie und Industrie der Kolloide.

The class of bodies known as colloids is named from one of its most representative substances—glue. Colloid means from its derivation, "glue-like". Some of the best known colloids are: silicic acid, aluminum hydroxide, gelatin, glass, glue, starch, albumen, resin, rubber and gum arabic. Some writers divide colloids into two classes: the reversible and the irreversible. The irreversible lose their colloidal properties on dessication, and become insoluble, but the reversible colloids re-dissolve after dessication. Gelatin is an example of the latter. After drying, it can be dissolved again in water to form a jelly or

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*Report before the North Carolina Section of American Chemical Society at Raleigh, June 22nd, 1910.

solution. Silicic acid is an irreversible colloid. This fact is taken advantage of in the determination of silicic in minerals. The gelatinous silicic acid is converted into the insoluble form by heating to drive off all the water.

A. A. Noyes, in his paper, referred to above, classifies colloids in another way. He first defines *colloidal mixtures* as "Liquids or solid mixtures of two or more substances, which are not separated by the action of gravity, however long continued, nor by filtration through paper; but are separated when the liquid is forced through animal membranes, the substance then remaining behind, being designated the colloid". He divides colloidal mixtures into "Colloidal Solutions" and Colloidal Suspensions." Solutions are viscous, gelatinizing, and not coagulated by the addition of salts. Colloidal suspensions are non-viscous, non-gelatinizing, but readily coagulable. Colloidal solutions possess characteristics of true solutions: osmotic pressure, diffusibility, and usually a limited solubility of the colloid at some temperature. Colloidal suspensions do not have these properties of true solutions, and manifest many similarities to macroscopic and microscopic suspensions. Prof. Noyes says, in giving this classification, that when more is known about the behavior of colloids, it is probable that this classification may be found to be one of degree rather than a distinction based on some very fundamental difference.

It seems to the writer of this report that a better classification than either of the above may be found when colloids have been studied more extensively.

The distinction was originally made between colloids and crystalliods. In recent years however, a number of crystalloids like sodium and potassium chlorides and barium sulphate, have been prepared in colloidal form. So that now the distinction is made between two different states rather than between two classes of substances.

The important properties of substances in the colloidal state are: (1) When dry they are amorphous and show a conchoidal fracture. (2) They form two classes of physical compounds, with liquids: jellies, and colloidal solutions. These are technically called "gels" and "sols". Gelatine furnishes an example of each. If it is dissolved in hot water we have a colloidal solution. When this solution cools it forms the semi-solid mass called a jelly or "gel". (3) When a colloid is heated with water and it expands to form a jelly, it exerts a very great force. This force has been calculated for starch by the use of Clausius's equation for bodies expanded by heat, and found to be 2073 kilos. per sq. cm. The expansion of colloids by water is a reversible and cyclical process, therefore Clausius's equation is applicable to it. The great force exerted by swelling wooden wedges used to split rock, has been explained as this colloidal expansion. (4) Colloidal substances are permeable to crystalloids but are more or less impermeable to other colloids. Dialysis is based on this property. The mixture of colloids and crystals which it is desired to separate, is placed in a bag made of an animal membrane, which is a colloid. This bag is then placed in running water. The crystalloid then passes through the membrane and is removed by the running water; the pure colloid remains in the bag. (5) When an electric current is passed through certain colloidal solutions the colloidal particles migrate towards the anode; particles of other collodial solutions migrate towards the cathode. It has been found that when solutions that migrate to different electrodes are mixed, they precipitate each other; while colloids migrating to the same electrode have no effect on each other. Colloidal solutions also coagulate on the addition of a very small quantity of an electrolyte. Often, though, an electrolyte which preciptates one colloid will have just the opposite effect on another, causing its gel to go into solution. When a colloidal solution is precipitated by an electrolyte, it is found that a very small amount of one or the other ion of the electrolyte is carried down with the coagulated colloid, and that on analysis of the solution, a corresponding amount of the same ion is lacking; (6) The property of colloids that has probably the widest technical application is that of adsorption.. Colloids may take up and hold acids, salts, etc., in such quantity that the resulting products may be mistaken for chemical compounds. This is the case with basic ferric arsenite 4 $Fe_2O_3$ $As_2O_3$ $SH_2O$, and a number of complex mineral silicates, which are now considered to be absorption compounds. The collodial solution of palladium absorbs about three thousand times its volume of hydrogen. Dyeing is largely an adsorption process, the dye being absorbed by the colloidal threads. (7) When observed with the ultramicroscope the particles in colloidal solutions range in size from very nearly that of the estimated size of the hydrogen molecule to hundreds of times as large. They all exhibit the Brownian movement which rapidly increases with decrease in size of the particles. (8) If a small amount of a reversible colloid (not enough to appreciably increase the viscocity of the solution) be added to a colloidal solution of gold, it makes the gold solution more stable, ie., less liable to coagulation. Also hydrochloric acid produces only an opalescence in silver nitrate solution containing a small amount of gelatin*

In general the addition of a small amount of a reversible colloid seems to prevent coagulation or the growth of crystals. It has a wide technical application.

The methods of preparation of colloidal solutions may be of interest. There are four general methods: (1) by simple solution as in the case of gelatin and albumen; (2) by electrical subdivision; Bredig prepared his colloidal solutions of the metals by forming an electric arc under water, between electrodes of the metal, whose colloidal solutions he wished to prepare; (3) by adding a small amount of an electrolyte to an insoluble jelly. The proper electrolyte causes it to be dissolved. For instance: stannic hydrate is rendered soluble by the addition of a drop of ammonia; (4) by chemical reaction in a solvent in which the resulting product is very insoluble.

Colloidal barium sulphate is prepared in this way by precipi-

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*Experiment. Two portions of silver nitrate in one of which is dissolved an empty gelatin capsule obtained from a drug store, are precipitated with HCl and filtered. Filtrate from the one containing gelatin is opalescent, the other is clear.

tation in glycerol. The alkali halides are prepared in colloidal form by precipitation in methyl alcohol.

So far I have given the most important properties of substances in the colloidal state and the general methods for their preparation. As colloidal chemistry is still a very new field the different workers are by no means agreed on the correct explanation of all the phenomena, I will try to give one or two of the most generally accepted theories concerning colloidal solutions and gels. Any such theory must offer an explanation of the electrical behavior of colloids, the movement of the particles, and their coagulation.

Most of the writers on colloids, though they express the fact in very different ways, agree that colloidal solutions form a regular transition from suspensions to ordinary solutions. That is to say, we can start with a suspension that settles out on standing, and by taking other suspensions of smaller and small particles, we can pass through colloidal solutions and finally when the particles consist of one molecule, arrive at ordinary solutions. The particles acquire an electric charge (by contact in a manner similar to the acquisition of a charge by glass rubbed with silk) by contact with the liquid, and as the particles become smaller and smaller the influence of this charge becomes very large in comparison with the influence of gravity, the Brownian movement then appears as the result of the mutual repulsion of similarly charged particles. As the particles become smaller and smaller, this motion increases very rapidly and prevents the settling of the suspension. When the particles approach the size of molecules the rapidity of the motion is enormous and we have crystalloidal solution.

The coagulation that takes place when two colloidal solutions of opposite sign are mixed is supposed to be due to the neutralization of the electric charges and the consequent cessation of the movement of the particles. When the motion ceases the attractive forces of the particles and gravity cause the settling.

The explanation of the character of the colloidal jellies is that they have a cellular, sponge-cake structure, the solid part of which is a solid solution of the liquid in the colloid. The spaces in between the solid part, corresponding to the pores of the sponge, are filled with a liquid solution of the colloid in the liquid. The tremendous force exerted by the swelling colloid is generally ascribed to molecular forces. Different writers are not agreed as to whether the mechanism of this force obeys capillary, surface tension or osmotic laws. Adsorption is also explained by this structure and these forces.

Some of the practical applications of colloidal chemistry will now be mentioned. First of all, its application to the study of physiology can be seen when we think that the whole body is made of colloidal substances. The blood has been found to contain in soluble form the same colloids that appear in the muscles and tissues. Colloidal jellies are used as media in which bacteria are studied. Nearly all foods are colloidal substances. From the number of references in the literature to medical journals I should say that the physiological application of colloidal chemistry was certainly one of its most important ones. Since this paper was written, a very interesting article, ''Some Colloid-chemical Aspects of Digestion, with Ultramiscroscopic Observations'' by Jerome Alexander, has been published in the Journal of the American Chemical Society.

The process of dyeing different kinds of fabrics is, in most cases, colloidal adsorption. A mordant is used to deposit a colloidal jelly in the thread and this absorbs the dye.

The artificial silk industry which now produces 50 per cent. of the silks sold, depends largely on colloidal processes. The cellulose is obtained in a soluble form and again coagulated in the form of very fine threads.

Celluloid, rubber and starch are colloids and consequently their manufacture is concerned with colloidal processes.

Photographic plates are coated with a colloidal solution of a silver salt in nitro-cellulose. One kind of photographic paper is simply a piece of paper coated with a mixture of potassium dichromate, a pigment and gum arabic. Under the action of light this mixture becomes insoluble.

Ice cream is given a smoother taste by the addition of a small amount of a protective colloid like gelatin. The gelatin prevents the formation of large ice crystals. A small amount of gelatin, albumen or gum arabic is added to candies to prevent the crystallization of the sugar. This is done in making marshmallows caramels, etc.

In the manufacture of pottery, tannin is added to the clay to make it more workable. The tanning industry is concerned with colloidal chemistry. In electroplating, a small amount of protective colloid is often added to prevent the formation of crystals and to give a smooth coating to the plating. The coloring of glass is a colloidal process. The colored glass being a colloidal solution of a metal. Ruby glass is a solidified colloidal solution of gold. These applications will serve to show the importance of this field of chemistry.

In conclusion, I wish to thank this section for having made me its reporter. It has been a pleasure to me to study this subject, and I hope that some of you may be interested in this new and interesting field of chemistry.

## A RECOLLECTION OF PROFESSOR W. K. BROOKS WITH CRITICISMS OF SOME OF HIS WORK*

By H. V. Wilson.

In going over my memories of Dr. Brooks I find that my mind does not separate him from his environment. I continually see him in the semi-communal life of the laboratory, whether in Baltimore or Beaufort, Woods Hole or the islands of the West Indian sea, which so stirred and charmed him. Even his home life with its restful, satisfying beauty was but a detached fragment of the other larger existence. I think of him as the central figure, wise and kind, of a circle of young men coming from many quarters, from New England, the Middle States, the West, and the South, from Canada, England and Japan, a society from which older members were always going out to honorable careers and into which new were coming to learn the ways and traditions of the school. Very different were we, but knit together from the start by the strong bond of a common interest, and presently by growing appreciation of him who made the school. It took us but a short time to learn that here was no mere work-shop, well organized and in which we might acquire the requisite degree of skill in a profession, but that we were in the company of a master mind, wide ranging in the fields of knowledge and inquiry, profound in contemplative thought, and with the acuteness of the observer who discovers what has been hidden.

As I dwell on the man and try to single out mental habits and attributes from the whole of his personality, I come to many that arrest and enchain my attention.

It is interesting to consider his practice and advice to begin-

*From the composite biographical sketch in the Memorial Volume to William Keith Brooks (Journal Experimental Zoology, special volume 9).

ners in the study of Nature. It was to start out, not from a general principle, but from some phenomenon that had caught the eye and become a nucleus for thought. Continued persistent observation and reflection circling round such a center would yield, he held, solid results in the shape of new facts and would sooner or later lead one into living contact with great questions. This method of work was eminently characteristic of his independent, individualistic temperament.

The serenity of Dr. Brooks impressed every one. In a mind so strong, active, and keen, calm temperateness was doubly noticeable. This peace of mind must have been due in part to the fact that his critical insight was unobscured by selfseeking. A firm gaze fixed on the distant goal held the immediately advantageous in its proper place, and gave him a confidence, a quiet boldness that we all recognized.

Brooks frequently said that he tried always to be a reasonable man. And in dealing with men and their ways I am convinced that reasoning did guide him in a remarkable degree. His logical habit of thought came in, however, for more congenial exercise in professional work. Do we not all remember the pleasure he had in the skilful disengagement of the idea from the mass of details, and in its portrayal, language and drawing mutually contributing to clearness?

I recall also his strong and helpful faith in the value of labor spent in searching out the order of the universe, the way things happen in nature. For, as he often said, such knowledge both makes the conscious life of man fuller and nobler, and is the basis on which rests all our control of natural phenomena.

The machinery of Professor Brooks' department, the lectures, set tasks and routine, was simple. Experience has shown, however, that it was not inadequate, on the contrary, that it was well adapted to the purpose in view. Brooks' underlying assumptions were that graduate students had come to stay some time, would work as hard as they could, and that they had enough independence of mind and enough elementary training to handle books and journals which record the actual state and progress of zoology. Of lectures there was one now and then from Professor Brooks on any subject. A round of lectures by older students in the department was given some years, and this was excellent practice.

The journal club was serious. It met weekly and the arrangement was such that each graduate student reported a number of times during the year. A reading club met weekly in the evening at Professor Brooks' house. Some pleasant book of general zoological interest, often one of travel, was read, after which came tea. In the laboratory again once a week readings of a more serious nature and with some discussion were held. The "Origin of Species" was in this way gone through, and "Agassiz's Essay on Classification."

Professor Brooks had compiled an elaborate list of the literature, with which it was supposed candidates for the doctor's degree were to make themselves familiar. It included the text-books of the period and important memoirs on the various subdivisions of zoology. The list was long. Perhaps some students completed it. But we all read with considerable diligence and it was the custom to make careful abstracts. On the basis of this common reading a good deal of informal talk and discussion was maintained among us.

We lived in the laboratory all day and the young men learned much from the older, especially in matters of technique. Brooks gave excellent suggestions on drawing and would occasionally go through the form of taking a micro photograph. A beginner in my time was usually given some material, referred to a paper or two on comparative anatomy or embryology, and told to verify the research. At intervals, frequent enough, Brooks looked at his figures, notes, and preparations and had something to say about the matter. Frequently before the first testing and forming exercise was completed, the man would be put at another. Two or three filled the year. Then came the long season at the seaside laboratory, in all probability the first for the student and teeming with experience. There was daily collecting, much study of living animals, much rearing of embryos and larvae. The pelagic fauna got in the tow net or at times by dipping came in for a good deal of attention. Numerous quick dissections were made, and quantities of notes and drawings. Brooks exercised little or no supervision over such work, but the older men were a great help to the younger. The larger manuals such as Balfour's Embryology, and later Korschelt and Heider, were fairly thumbed. The industry and "go" of Brooks' summer laboratories were remarkable, the lamps lit in the evening, and some one frequently sitting up all through the night to "follow a development." Toward the end of the season, when a little perspective had been acquired and mere mass and variety began to pall, a special form or two was singled out as promising something in the way of new results, and the path of research was thus opened up. The material so collected was studied in detail during the folllowing winter. More intensive reading bearing on the problems as they became defined was undertaken. Informal, short, but helpful talks about the work were had with Brooks from time to time. He would examine particular preparations, quickly to be sure, or would criticise figures. There was never any leading or "nursing" on his part. By the end of the year, though, some grasp of the methods of research had been acquired, and the following summer at the seaside usually found the student able to pursue the line of inquiry on which he had started, or to strike off into an associated field.

*Studies on Heredity.* As early as 1876 in a paper entitled, "A Provisional Hypothesis of Pangenesis" Brooks began to deal with questions of heredity and variation. His thinking in this direction took shape and led in 1883 to the publication of a volume under the title of "The Law of Heredity." The central point in the theory he presented is the conviction that the reproductive elements are, contrary to the usual opinion, not alike in function. In support of this conclusion the author draws arguments from the facts that hybrid offspring resulting from reciprocal crossings are often very different; that the offspring of a male hybrid and the female of a pure species is much more variable than the offspring of a female hybrid and the male of a pure species; that a structure which is more developed or of more functional importance in the male parent than it is in the female parent is very much more apt to vary in the offspring than a part which is more developed or more important in the mother than it is in the father. These and other facts convinced Brooks that the ovum and sperm cell are not only different morphologically, but that they differ profoundly in function as well.

In developing this idea into an explanatory theory of the way in which hereditary transmission is accomplished, Brooks borrows from Darwin's hypothesis of pangenesis, and assumes the existance of material particles, ''gemmules'' which are thrown off from the body cells. Unlike Darwin, however, he assumes that such particles are only thrown off at particular periods, when the body cells are disturbed in function through some change in their environment. The gemmules may penetrate an ovum or a bud, but it is the male germ cell which has gradually acquired during the evolution of the metazoa the peculiar power to gather and store up gemmules. The ovum on the other hand has acquired a very different nature. It contains material particles which correspond to the hereditary characteristics of the species. Thus in the case of a fertilized egg, as in that of a parthenogenetic egg, the great bulk of the development is due to the properties of the ovum itself. The gemmules brought in by the sperm cell unite with homologous particles in the ovum and so composite particles are produced which, as the egg segments and develops, give rise to cells that are strictly hybrids and which therefore exhibit variation. The ovum thus is the conservative element which transmits the characteristics that have already been acquired. The male cell is peculiarly that which stores up the disturbing effects of a changing environment. It especially leads, therefore, to variability in the offspring, to the production of individual differences.

This ingenious hypothesis enables Brooks to explain a great variety of inheritance phenomena and to overcome several serious objections to the unassisted selection theory. Whatever truth there may or may not be in the special ideas of the book, it remains today a stimulating and suggestive contribution, and it is properly looked on as one of the factors that have in recent years focussed the attention of the biological world on the problems of heredity.

Minor papers dealing with heredity and evolution, the causes of variation, and the determination of sex, appeared from time to time. Sections of the "Foundations of Zoology" (1899) show too that Brooks' interest in the questions discussed in the "Law of Heredity" remained active during life. Two of his last addresses (1906, 1909) deal with our concepts of heredity and variation. In these he emphasizes the fact that the nature of an organism is not implicit in the egg, or in the organism indeed at any time of its life, but that it depends on a continuous reciprocal interaction between the organism and its environment. Such interaction leads in any particular case to a result which could not be calculated from a knowledge, however complete, of the egg itself since it is dependent not only on the organism but on the action of the total environment. The outcome of such interaction is the production of individuals which are never quite alike, although they may resemble one another closely. The occurrence of likenesses, or inheritance, and the occurrence of differences, variation, are thus not two processes but two views of the single process of reciprocal interaction. The idea that they are distinct is an error into which we fall through concentrating our attention at one time on the resemblances, and again on the differences between individuals. These considerations, he thinks, show the uselessness of theories which postulate an inheritance substance and explain individual differences as the result of various combinations of its particles.

These addresses show that Brooks has in some measure shifted his standpoint since the time of the "Law of Heredity". He no longer is in a mood to employ evolution (determinant) hypotheses to account for development. He now looks on the development of the individual, and that of races also, as epigenetic in nature. What will be the outcome of an individual egg depends on the interaction between egg and environment, not on a determinate mechanism in the egg. The pre-cambrian fauna has given rise to the living beings of today. But the latter were not implicit in the former, for with the same ancestors the course of evolution might have been different had the sum total of the environmental influences been different.

*Writings on the Principles of Science.* Brooks dwelt often in conversation and in minor writings, and always with an earnest pleasure, on the nature and intellectual value of what we can learn. His thoughts in this field of the principles of science were eventually embodied in his lectures on the "Foundations of Zoology" (1899). This remarkable book "belongs to literature, as well as to science. It belongs to philosophy as much as to either, for it is full of that fundamental wisdom about realities which alone is worthy of the name of philosophy."

The "Foundations" is essentially a discussion of the nature of scientific knowledge. It is the wise talk of an experienced, reflective naturalist of ripe years addressed primarily to younger fellow-workers in the fields of science. The argument which makes its way through pages and sometimes whole chapters of illustrations and digressions, interesting and suggestive in themselves, proceeds about as follows:

Our knowledge of nature comes through experience. Through experience we learn that one sort of event follows another, and this sequence, which we come to expect, constitutes for us the order of nature. Nevertheless there is no reason to believe that there is an inherent necessity in this order, for we never perceive the presence of any intrinsic causal connection between the preceding event (cause) and the succeeding one (effect).

When our knowledge of any part of nature has so far developed that we know the order of events, and so can predict the later steps in the series of occurrences, once the earlier have been noted, we say that we understand and can mechanically explain that particular set of phenomena. At present a gap separates vital from non-vital phenomena—to say that life is the sum of the physical properties of protoplasm is to make a dogmatic assertion, although to gainsay it is to make another. But with the progress of science this gap may be bridged over at some time. Should it be bridged over, and life in all its aspects be found to be "protoplasmic", still we should not know *why* synthesis of compounds results in an organism or *why* a vital action is the outcome of protoplasmic changes. In respect to organisms and vital actions we should still be where we are now in respect to simple gravitation phenomena, for with respect to them all that we can say is that the stone will fall (if the future be like the past), but why it should fall we do not know.

This being the nature of our knowledge, present and future, what should the biologist seek to discover, and what are the problems that peculiarly concern him? Life is defined as a continuous adjustment of internal to external relations (Spencer), and it is pointed out that synthesized protoplasm, even were it capable of nutrition, growth, reproduction, and contraction, would not be a living thing if it were not also able to maintain persistent adjustment to the shifting world around it. The essence of the living thing and that which distinguishes it from other forms of matter is this very adjustment. Fitness, adaptive response, is therefore what we should seek to study in biology. The mechanism itself is of subordinate importance. Study it as we may, we cannot thus go far forwards, since our knowledge of nature never includes a perception of any necessary causal connection between events, such as would make it possible to discover vital phenomena by reasoning deductively from protoplasmic peculiarities. A corollary of practical import is that the naturalist should endeavor to study living things in connection with their environment.

Biology being thus defined as the study of adaptive response, the nature and evolution of man's reason and knowledge fall within its scope. For these are conceivably but the outcome of adaptive responses in the beginning as simple as the geotropism of a seedling's radicle. The ability, for instance, to make a distinction between what in practical life we call a truth, a real occurrence, and an error or illusion, is to be looked on as a useful response that has been acquired through selection. Man's knowledge, then, is of the peculiar kind that is useful to him. He may not yet know as much as is good for him, but he at least has acquired a store of the kind of knowledge that preserves him in the struggle for existence.

Viewing man thus from the biological standpoint Brooks attempts to deal with two human characteristics, the consciousness that the will is free and that the individual carries a moral responsibility. These, like all other vital characteristics, he thinks, may possibly sometime be shown to be a part of the order of nature and in that sense mechanical. "Rational action may sometime prove to be reflex from beginning to end." And yet in the face of this possibility, Brooks would still maintain that the will is free and moral responsibility real. To some this will seem a difficult thesis.

Underlying the scientific inquiry as to the character of our present knowledge and of that which possibly we may acquire about nature, is the metaphysical question, "What is nature?" This question Brooks does not attack in the fashion of constructive technical philosophy. He makes no attempt to define reality. His purpose in dealing with the matter is plainly the practical one of showing us what we need not believe. He says in effect, if then our knowledge of all nature is and will continue to be of one sort, that phenomena follow one another regularly and (supposing the future to be like the past) in predictable fashion, but without our ever learning why they so follow one another, there is not now nor will there be in the future any necessity drawn from science to believe in a fixed, necessary, determinate nature. If in any quarter it is imagined that the progress of science necessitates or may necessitate such a belief, this is a grave error: in his own words, "The belief that the establishment of scientific conceptions of nature shows that after the first creative act, the Creator has remained subject, like a human legislator, to his own laws, is based upon utter misapprehension of science, and upon absurd and irrational notions of natural law." In the second place we are in no wise forced to believe by anything in science that protoplasm and life are necessarily linked together: "* * * if it be admitted that we find in nature no reason why events should occur together except the fact that they do, is it not clear that we can give no reason why life and protoplasm should be associated except the fact that they are? And is it not equally clear that this is no reason why they may not exist separately?"

The next step in this survey and analysis of fundamental aspects of nature brings us to positive belief itself. As so often said, science quite fails to find in matter and motion any intrinsic virtue which sustains and directs the sequence of phenomena, and is absolutely restricted to the discovery of the mere sequence which itself calls for (metaphysical) explanation. Hence there is nothing in science which has any bearing on the causal origin or on the reality of anything in nature, and we must go elsewhere for the foundations of the belief that we may entertain in respect to such matters. Brooks believes that "nature is intended" to be as it is, and is a language which a rational being may read. Since the rational being is perhaps himself a part of nature's mechanism, this is equivalent to saying that one part of the mechanism is cognizant of the purpose that animates the whole. This purpose is the effect of a power, a sustaining and directing intelligence outside nature, to which both the origin of nature and its maintenance from day to day are due. It is not something which once for all set a determinate cosmos spinning along the path of time with a full complement of "eternal iron laws." It is something which is at work now, under every phenomenon. This is obviously Brooks' belief, although being no propagandist he is far from enforcing it, indeed leaves it in a measure to be inferred. What he wishes to make plain is that science does not tell us why events happen as we learn they do, and so it tells us nothing of ultimate reality. The question why the events we expect (from experience) should be those that come to pass, concerns not science but "the natural theologian; for it is the same as the question, What is the cause of Nature? To this all must seek an answer for themselves; for each has at his command all the data within the reach of any student of science."

# RECENT FOREST REPORTS OF THE N. C. GEOLOGICAL AND ECONOMIC SURVEY

By Joseph Hyde Pratt

Two reports have recently been issued by the North Carolina Geological and Economic Survey relating to the forests of this State. The first of these is a report on Forest Fires in North Carolina during 1909, by J. S. Holmes, Forester of the Survey, published as Economic Paper No. 19. The statistics given in this report were collected in co-operation with the United States Forest Service. This report has been issued on account of the enormous loss North Carolina sustains each year as the result of forest fires, and it gives the result of an investigation regarding the number of forest fires, the amount of damage they did, their causes, and whether it would have been possible to have prevented any of them. Although the Survey was not able to obtain as full information as was desired, yet the statistics given are of considerable importance and show the need of some legislation to prevent, as far as possible, this enormous waste that is caused each year by forest fires.

Fire is undoubtedly the greatest enemy to the forest. It has been estimated by the National Conservation Commission that in the United States the loss by fire on standing timber for the past thirty years has averaged $50,000,000 a year, and this takes no account of the destruction of young growth. The statistics for 1909 showed that North Carolina sustained a loss of over $500,000 from forest fires. The fires which caused this damage were chiefly due to carelessness. To overcome this careless attitude on the part of the people and interest both private effort and state co-operation in the fight against forest fires, public opinion on this subject must be awakened.

The second report is on the Wood-Using Industries of North Carolina and was prepared by the North Carolina Geological and Economic Survey in co-operation with the United States Forest Service. It was prepared by Roger E. Simmons, under the supervision of J. S. Holmes, of the North Carolina Geological and Economic Survey, and H. S. Sackett of the United States Forest Service, and is published as Economic Paper No. 20. This report deals with the Wood Using Industries of North Carolina as follows:

(1) Those manufacturing directly from the log a finished product, which cannot be changed by any further process of manufacture, such as excelsior, handles, veneer boxes, or mine rollers; (2) those using rough lumber and by the application of skilled labor and wood-using machinery convert it into such finished products as furniture, boxes, flooring, etc. The various tables in this report show the sources of the wood used, the kinds of lumber demanded by the wood-working factories, the price paid for each species delivered, the quantity consumed, and the purposes for which it was used.

An investigation of this character should be of value in a number of ways. To the State of North Carolina it should be of considerable assistance in forming an intelligent forest policy, and in presenting the advantage the State offers to wood-using industries to locate in it. The timber owner, and even the farmer who has a few scattered trees to sell, can learn from this report where a market can be found. To the sawmill operator it may suggest a use for wood which he previously considered of little commercial value. To the manufacturer who is under the necessity of looking beyond his own State for all, or part of the lumber needed, it will furnish a source of fairly accurate information concerning a region most likely to supply his needs. The merchants throughout the country who handle wood products can study to advantage the report of what North Carolina has to sell or wishes to buy. For the people at large it has a statistical value, and gives much general information.

It gives valuable information concerning the forms, uses, and grades in which the factories desire the lumber, and also the woods most suitable for specific uses. The chief purposes of this report are to give needed information regarding these industries, to stimulate trade by bringing together buyer and seller, and to show the citizens of North Carolina the wisdom of perpetuating her valuable wood-using industries by the adoption of an intelligent forest policy. Two appendices have been added to this report. The first gives a list of the different kinds of woods that are found in North Carolina, together with the various purposes for which they are used, and the second appendix gives a list of the wood manufacturers of North Carolina under the heads of the products which they manufacture.

The value of the timber crop in North Carolina is exceeded only by that of the cotton and corn crops. According to the United States Census Bureau, the value of the lumber cut in this State amounted in 1908 to $15,000,000.

The foregoing report shows that half of this lumber was purchased by firms in this State and manufactured by them into a finished product. For this lumber, together with a small amount of logs, billets, and timber in other forms which they used, these firms paid something over $10,000,000.

This enormous industry has been dependent for its supply of raw material almost entirely on timber that has grown up under natural conditions, the present owners being in no way responsible or assisting in its production, much of the timber having been growing for 200 to 300 years. As the old timber disappears, and it is rapidly doing so, the methods of the producers will have to change; either this timber will have to be procured outside the State or these large and valuable industries, second only in importance to cotton manufacture, will have to shut down.

As long as both the growing and manufacture of this timber can be carried on profitably in this State we cannot afford to give up either part of this two fold industry. North Carolina probably contains as large a proportion of mountain land specially suitable for the growth of hardwoods, which is what most of these industries require, as any other State. We can, therefore, grow the raw material more cheaply, and furnish it to these factories at a lower price.

This report is intended as an incentive to improvement and as an aid in bringing about better conditions, partly in demonstrating the value of our forests to the people of the State, but chiefly by enlarging the market for the lower grades of wood by letting other parts of the country know what North Carolina can furnish them.

By protecting the forests from fire so that the annual rate of growth can be continually increasing, and by closer utilization, thus preventing waste in the woods and at the mill, there is no reason why the annual yield of our forests cannot, after a comparatively short time, be doubled.

If as much care and foresight were exercised in the growing, protection, harvesting, and marketing of the raw material as is now given to the manufacture of the finished product, there need be no fear of an impending timber famine on the part of the wood-using industries of North Carolina.

# JOSEPH AUSTIN HOLMES*

By Collier Cobb

The director of the recently established Federal bureau of mines illustrates the helpfulness of a proper heredity by an advantageous environment. But this environment has been one that his heredity forced him to seek, and his own rigorous interaction with whatever environment he has made for himself, has been effective in placing him in charge of one of the most important bureaus of our government. He has risen to the directorship of this bureau, which his own energy has created, by sheer force of merit, when all political odds and party expediency seemed against his appointment. If that education is best which gives one the power to select his own environment and then bring about the adaptations, one has to look far afield before finding a better educated man than Joseph Austin Holmes.

Born at Laurens, S. C., November 23, 1859, son of Rev. Z. L. Holmes and his wife N. Catherine Holmes, born Nickles, Joseph A. Holmes came of the best Southern stock. For generations he had been well-born, his family on both sides having always been people of character, means and position. Coming into the world in South Carolina just before our civil war, his childhood and youth were spent under circumstances well calculated to try the mettle of a boy, and in the duties of the home he early came to bear a man's part.

The son of a Presbyterian preacher, who was himself a lover of nature, the boy was reared in a home of culture and refinement. The home was a large octagonal house made of reinforced concrete, occupying the center of ample grounds on the outskirts of the village, and having every convenience that the ingenuity and skill of its occupants could devise and supply. The house was supplied with running water, which a hydraulic

*Reprinted from the Charlotte Observer.

ram brought up from the branch. This was true of the Holmes home at a time when the trains that came into the sleepy little village ran from Alston over wooden rails capped with strap-iron. But the home had an excellent library, and one could see in it here and there instruments and appliances for the study of the realm of nature, most of them made in the workshop of the home. The writer recalls especially a high-grade telescope made and mounted by the minister himself.

One son from this home became a lawyer, but later entered the ministry of the Presbyterian Church. The children got the best of their instruction at home from their parents, but they also attended the Laurens Acadamy, famed in its day for the thoroughness of its instruction. Joe, who was skilled with his fingeres and handy with tools, went to Cornell, where he made his own living and took his degree of Bachelor of Agriculture in 1881, with visions of rehabilitating the barren farms and mending the broken fortunes of his stricken State.

Immediately upon his graduation he was elected to the professorship of geology and natural history in the University of North Carolina, and entered upon the teaching of subjects that now require the entire time of nine specially trained men. As soon as he had acquainted himself with the geography and geology of the State, he began an active campaign for the reorganization of the North Carolina Geological Survey and for the building of good roads throughout the State. In both endeavors he was eminently successful. The State survey was established in 1891, when Prfessor Holmes became State Geologist; and from 1885 to 1900 he increased the annual tax money for public roads from ten thousand dollars to three quarters of a million dollars, thus adding more than a thousand miles of macadamized roadway to the capital of the State.

Professor Holmes was the most public-spirited citizen of Chapel Hill. He was a member of the board of aldermen, and interested himself especially in the sanitary condition of the town and in the grading and macadamizing of the streets. He carried around with him less of himself and more of the work in hand than any other man I have ever known. He literally lived in his work, without the least regard to its relation to himself. So true was this that, while State Geologist, he more than once spent so much of his annual appropriation in prosecuting the work of the survey that he did not leave money enough to pay his own salary.

While professor in our University he secured the passage by Congress of a bill appropriating money for the building of a marine biological laboratory at Beaufort for the use of the United States fish commission. By some oversight, the bill did not carry an appropriation for the purchase of the ground on which to erect the building. But Mr. Holmes invited a number of universities to contribute to the purchase of an island in Beaufort Harbor on which to build the laboratory, the place affording exceptional opportunities for study as it is the meeting-place of the Northern and Southern fauna and flora of the sea. The Universities of Virginia, North Carolina, South Carolina, Georgia, and Johns Hopkins responded liberally. The island was purchased and presented to the government, and now each season sees a number of trained men carrying on at Beaufort investigations of inestimable value to our fisheries industries.

Professor Holmes organized and directed the Department of Mines and Metallurgy of the Louisiana Purchase Exposition in 1904. He was in charge of the United States Geological Survey laboratories for testing fuels and structural materials, at St. Louis from 1904 to 1907, and at Pittsburg since 1908. For several years he has been chief of the technological branch of the United States Geological Survey, in charge of the investigation of mine accidents. Since his employment by the national government he has not only continued his work for the improvement of public roads, but has made a more than national reputation through his enlightened efforts to prevent waste in utilization of the country's mineral and fuel resources, and to safeguard the lives of miners.

His investigation of fuel resources alone, begun at the St.

Louis Exposition, gave him prompt international recognition, and he was decorated by the governments of Germany, Belgium, Italy and Japan. In recognition of this work, the University of Pittsburg conferred on him the degree of doctor of science, and at the commencement of 1909 the University of North Carolina made him a doctor of laws.

Dr. Holmes is a conservationist of the type of Garfield and Pinchot and is an administrative officer of rare ability. He has the rare gift of selecting the right man for a given piece of work and leaving him to do it in his own way, under no circumstances burdening himself with the details of tasks which the men he chooses are fully competent to carry out. This was admirably illustrated in his investigation of fuels at St. Louis, at Pittsburg and at the Jamestown Exposition, as well as in his survey of methods of conservation of resources and protection of human life in use in the older mining communities of England, Germany, Austria and France. His work along these lines was so thoroughly done that mine owners and employes alike petitioned for the establishment of a permanent bureau of mines, and no one of them ever imagined that anyone but Dr. Holmes would be considered for chief of the bureau. When the organization of the Bureau was intrusted to other hands, such a cry of indignation arose throughout the mining districts of the entire country that President Taft could hardly have done otherwise than give the permanent appointment to Dr. Holmes.

He cannot be better described than in the words of Dr. C. Alphonso Smith, when presenting him for the degree of doctor of laws at our university commencement as "A man of seasoned common sense, of winning personality, and of practical efficiency in all that he undertakes."

Chapel Hill, N. C., Sept. 22, 1910.

## EARLY ENGLISH SURVIVALS ON HATTERAS ISLAND*

In the *University of North Carolina Magazine* for February last, Mr. Collier Cobb gives some interesting examples of survivals of old-time speech and manners in a corner of the United States which has, to within the last few years, remained surprisingly untouched by modern influences, viz., the sand reefs of the North Carolina coast, particularly Hatteras Island. Before the advent of motor boats, just a decade ago, this formed a sort of World's end, three days' journey from anywhere, and its mild-mannered people were living under much the same conditions as three centuries ago. Hatteras island is an elbow-shaped sand-spit, 40 miles in length measured around the elbow, and from half a mile to 5 miles in width. It lies along the very border of the continental shelf, 100 miles beyond the normal trend of the coast, between 35 degrees and 36 degrees N. Lat. The everyday speech of the people contains words and expressions familiar in old English usage, but, so far as the writer is aware, hardly to be met with in any part of the United States at the present day. Such are: the verb to travel (in the sense of to walk as opposed to any other kind of locomotion); acre (in the sense furlong); country (meaning the opposite mainland, as opposed to the islands); and many others. The first named is to be found so in Hakluyt's 'Voyages,' and is still to be met with in various corners of the British Isles. Old English melodies are still to be met with in Hatteras Island, though the songs of the mothers and grandmothers are well-nigh forgotten by the daughters. The writer holds that the lost colony of Roanoke may have found refuge there, while the above survivals might also bea ccounted for by wrecks known to have taken place in this locality in 1558 and 1590. It may be regretted that the levelling influences of "civilization" are already making even Hatteras like the rest of the world.

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*Reprinted from *The Geographical Journal* (London: The Royal Geographical Society), September, 1910.

## CORRECTIONS.

Professor John F. Lanneau has requested us to publish the following correction: In Proceedings of the N. C. Acad. of Science, Vol. 26, No. 2, p. 57 of this Journal, paper on "The Locus of a Moving Point, etc.," sentence "If K-1, the circles are of infinite radius, and are tangent at O," the clause should read, *and pass through O.*

Insert map of The Landes and Dunes of Gascony to face p. 82.

P. 82, line 2: for *feattres* read features.

P. 83, line 27: for *insolated* read isolated; line 35, omit fifth word; line 37, for *upply* read supply.

P. 84, line 2: for comma place period at end of sentence; line 7, for *Pineaster* read *Pinaster;* line 14, for *popular* read poplar.

P. 85, line 12: for comma place period at end of sentence; line 26, for *steritity* read sterility; line 31, for *insolated* read isolated.

P. 87, line 2: for *inalnd* read inland; line 24, for *eastern* read western.

P. 89, line 15: for *ses* read ces; line 24, for *solid* read sand.

P. 90, line 3: for *it to* read to it.

P. 91, line 5: for *end* read and.

In sketch of Joseph Austin Holmes, p. 167, line 2, insert *influenced* after *heredity.*

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## TABLE OF CONTENTS

JOURNAL

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VOL. XXVII MAY, 1911 NO. 1

# A STUDY OF SOME EPITHELIOID MEMBRANES IN MONAXONID SPONGES

H. V. WILSON,

*Professor of Zoology in the University of North Carolina*

TWENTY-ONE FIGURES

In the course of some experiments dealing with the regenerative power of the tissues in certain monaxonid sponges, it became necessary to learn the histological peculiarities of the epidermis in these forms It soon developed that the adult epidermis in these species did not conform to the type usually thought of us as well nigh universal in sponges. A study of the regenerationof the epidermis in cuttings was then undertaken, rather with the idea of its throwing light on the adult structure. During the study of the epidermis some new facts as to the way in which pores close were made out. Finally for the purpose of comparison with the epidermis, the canal epithelium in a suitable species was studied.[1]

## THE EPIDERMIS IN STYLOTELLA.

The most abundant sponge in Beaufort harbor is Stylotella heliophila, a form which I have described in a paper now in press for the U. S. Bureau of Fisheries. The genus falls in the halichondrine monaxonida. The sponge has well marked ascending lobes

*Reprinted from *The Journal of Experimental Zoology*, Vol. 9, No. 3.

[1]The work was carried on during the summer of 1909 at the Beaufort Laboratory of the U. S. Bureau of Fisheries. My thanks are due to Hon. Geo. M. Bowers, U. S. Commissioner of Fisheries, for a place in the laboratory, and to the Director, Mr. H. D. Aller, for his kindly aid during my stay.

of conical shape which bear terminal oscula. The pores are scattered over the whole surface. Spaces of considerable size (subdermal cavities) belonging to the afferent system lie close to the surface, and as is customary in such sponges imperfectly separate a thin superficial layer known as the dermal membrane from the inner mass of the sponge body. The dermal membrane contains no flagellated chambers, or only a very few scattered here and there, and is made up of a thin sheet of mesenchyme containing spicules, which is covered on the outer surface by the epidermis and on the inner surface by the epithelioid membrane forming the wall of the subdermal space (and of the canal in general) According to the current conceptions of the histological structure of sponges we would expect to find the epidermis and canal walls both to consist of a single layer of flat epithelium cells (pinacocytes.)

Actually I find that the epidermis of this sponge consists of a thin protoplasmic sheet studded with nuclei and exhibiting absolutely no cell boundaries. It is a syncytium. Cell boundaries are sometimes overlooked, but it seems to me that the variety of his tological methods I have practiced makes it certain that cells do not exist.

*Results with material fixed in alcohol.*

Comparison with living tissues shows that strong alcohol, absolute or 95 per cent, is an excellent fixative for sponge tissues I use it in liberal quantities, and very shortly after the immersion of the piece of sponge, change to fresh alcohol, changing again after a few hours. The precipitate which alcohol unfortunately causes in seawater has scarcely time to settle on the sponge if the first change be made quickly. Moving the piece about in the alcohol also helps to keep the surfaces clear of the precipitate. Suitable pieces were stained in toto with haemalum and were then imbedded, some in celloidin, some in paraffine. On the whole I recommend the celloidin, but the paraffin preparations were satisfactory. After the xylol bath I add soft (40° melting point) paraffine to the xylol, warm the mixture up gradually and imbed 30 minutes in soft and 30 minutes in harder (50°--55° melting point) paraffine. Very thick tangential sections are made. Such sections are far better than thin ones. They afford many places where, owing to the transparency of the tissues underlying the epidermis, the latter can be well seen. The sections were given an after stain with congo red, or with Delafield's haematoxlin followed by congo, and were mounted in balsam. To obviate the possible ill effects of imbedding, strips of the epidermis were torn off with forceps from the alcoholic material, were stained in haemalum and congo red, and mounted in balsam. Most of the pieces obtained in this way are too thick for study, but occasionally very thin strips peel off.

As is well known the pores of sponges close and open. Preparations of the epidermis with the pores widely open were made from sponges that had been kept in a live box. In a live box placed where the tidal current is good, the sponge is usually found with the oscula and pores fully open and the canals dilated. If the sponge so expanded be suddenly plunged in the fixative, the pores will not have time to contract. More useful preparations are those in which the pores are closed or half closed. Sponges that have been kept a short time in running aquaria are found to be in this condition.

A part of the dermal membrane as seen in a thick tangential section is shown in fig. 1 Some of the pores are completely open and others nearly so. The wall of a small subdermal cavity is indicated by the line *s. c. w.*, and into this cavity the pores open. Beyond *s. c. w.*, we come to a thicker part of the body separating the subdermal space shown from neighboring ones. In this part a few conspicuous mesenchyme cells, *m. c.*, appear. They come into view when the microscope is focussed just below the surface of the sponge. The canal wall shows some of the lining cells, *c. c.*, as seen in optical section. They also appear of course only at a focus below the surface of the sponge. Over the subdermal cavity the figure shows the epidermis in focus. It appears as a continuous thin protoplasmic sheet without cell boundaries and studded with nuclei, *ep. n.* On focussing below the epidermis the mesenchyme cells of the dermal membrane would come into view. Below the mesenchyme lies the inner covering of the dermal membrane, an epithelioid layer continuous with the canal lining in general. Round most of the epidermal nuclei the protoplasm is aggregated, forming thickened more deeply staining areas which shade off into the internuclear portion. The structures marked *p. m.*, which I propose to call pore membranes, and which so far as I know have not been described, are extensions of the epidermal sheet over the pores. These extensions are so thin that they afford an especially favorable opportunity for studying the intimate structure of the epidermal layer. Their nature is learned when the process of pore closure is studied, and it will be well now to give a description of this process.

The dermal pores of the monaxonid sponges are customarily referred to as mere perforations of the dermal membrane. They are in reality short canals leading from the exterior into the subdermal chambers. Ordinarily the dermal membrane, while thin, is of such thickness that the actual aperture at the surface of the sponge is distinguishable, on focussing, from the canal itself. Thus in fig. 1, the pore membrane, *p. m.* partially closes the aperature and is distinctly seen when the epidermis is in focus. On focussing a little lower the wall of the canal itself *p. c.* comes into view as a distinct line which often exhibits a nucleated thickening or two. The nucleated thickening may as in the case of two of the pores shown in figure 1 extend out into the mesenchyme in the shape of a slender process. I propose to restrict the use of the term pore (viz., dermal pore), to the actual aperture, and to designate the short canal as the pore canal.

When the pores are widely open as is the case with pore 1, in fig. 1, there is no sign of a pore membrane. The epidermis is directly continuous at the edge of the pore with the lining of the pore canal. But even when the sponges are fixed at once on being taken from the live box, some of the pores will be partially closed and will show the pore membrane, *p. m.* This thin extension of the epidermal sheet in sponges so preserved will usually be found barely extending beyond the margin of the pore and it may or may not include a nucleus. It is a single thin layer which yet is continuous with both epidermis and the lining of the pore canal. Since it has the structure of the epidermis I speak of it and regard it as an extension of that layer. If the sponge has been kept in an aquarium a short time, preparations show that the pores are for the most part about half closed. In fig. 3 two such pores are shown as they appear in a thick tangential section similar to that from which fig. 1 was made. The pore membrane, *p. m.*, here extends well over the pore canal. If the sponges have been kept some time in the aquarium, regions will be found in which the pores are closed. Fig. 2 represents the dermal service of a thick tangential section. The region shown lies over a subdermal cavity and the pores are closed. The outlines of the pore canals, *p. c.*, are visible on focussing just below the surface. The thin sheet, *p. m.*, covering in the pore canal is the pore membrane. A comparison of such preparations shows plainly that the pores are closed by a thin extension of the epidermis over the pore canal.

Owing to the peculiarities of the species, especially unevenness of surface, abundance of spicules, and abundance of amoebocytes, it is well nigh impossible to observe the closure of the pores in living preparations of the dermal membrane as made from the normal sponge. Free hand tangential sections of the living sponge were sliced off, but these proved of no value. Pieces were cut off from the upper part of the oscular lobes in very transparent regions and where the wall of the lobe is thin, but these again were useless for the purpose. I did succeed, however, in observing the closure of the pores in life by practicing the following method.

Free hand sections about one-eighth inch thick were made transversely through an oscular lobe, and therefore directly across two or three of the main efferent canals. Such a section when cut is a circular piece of sponge tissue perforated by the segments of these canals. The segments of the canals are of course open above and below at each surface of the section. If such a section be kept a day in an aquarium a new dermal membrane develops over both surfaces and over the open ends of the canals. The new membrane closing in the canals is smooth and contains but few spicules. If the section now be mounted in sea water under a cover glass the new membrane over the canals may be studied with a high objective. It will be found to contain pores and one may actually see that these are closed through the creeping of the most superficial layer of the dermal membrane (newly formed epidermis) across the pore, *i. e.*, over the aperture of the pore canal, thus giving rise to a pore membrane.[2] As to the opening of the pores after closure by the pore membranes, I have no actual observations, but it is obvious that the pore must reappear as a perforation in the membrane, which the recedes towards the margin of the pore canal.

The question may be asked, is the pore canal a permanent structure, or does it too close up? Since the pore canal perforates the dermal membrane its closure obviously could only be brought about through an extension of the mesenchyme of that membrane. In Stylotella I always find the pore canals distinct even when the pores are completely closed. Hence the pore canals must be regarded as structures that are permanent in ordinary conditions of the sponge. My observations on Reniera and Lissodendoryx (vide infra) nevertheless show that the pore canal itself may be partially or completely obliterated in monaxonid sponges.

Another question may be asked before we leave this matter of the pore and closure. Is there any one nucleus that is especially associated with a pore membrane? An examinatian of figs. 1, 2 and 3 shows there is no such nucleus. The pore membrane may spread to a considerable distance over the pore canal before any of the epidermal nuclei enter it (fig. 3), and when the pore is completely closed (fig. 2) the membrane may show a nucleus somewhere near its center or again one or two nuclei near or at

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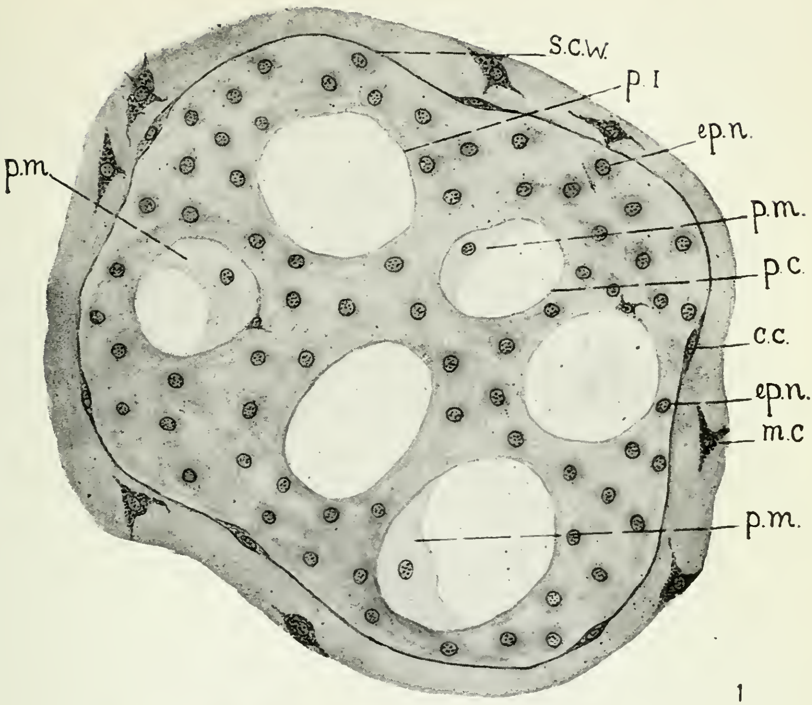
[2]In the healing up of such a section a considerable rearrangement of the canal system certainly takes place. A new osculum is established, and this apparently may develop at any point on the surface of the piece. Pore canals lead through the newly formed dermal membrane into what were originally main efferent canals.

PLATE I.

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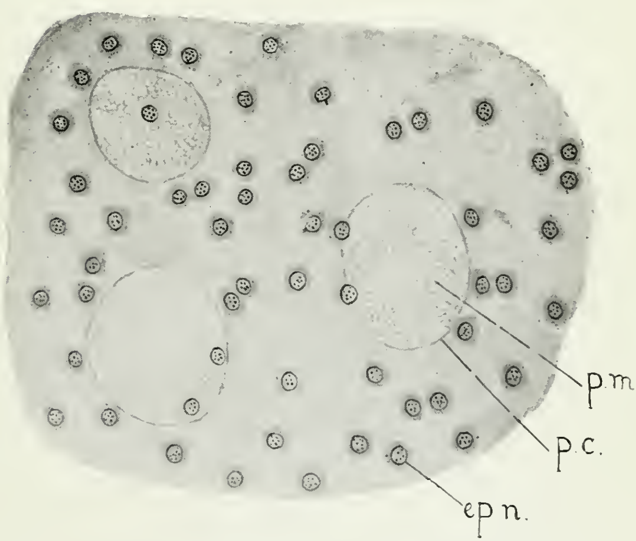


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its margin. The epidermal nuclei are irregularly distributed, in some spots close together, in others farther apart. This is well shown in fig. 2. These nuclei moreover are all alike. The facts would seem to indicate that the epidermal sheet of protoplasm spreads of its own initiative over the pore canal, and that the nearest nucleus or nuclei are simply drawn into it. In Reniera on the other hand there is always one nucleus at the margin of the pore and this nucleus is (perhaps only passively) associated with the formation of the pore membrane.

Some details in the structure of the epidermal layer remain to be mentioned. The irregular distribution of the nuclei has been noted. They are small and uniformly exhibit only a nuclear membrane and a few chromatin granules in the nucleoplasm. No cases of division were observed, although mitotic figures in amoebocytes of the mesenchyme were noticed not infrequently. Round each nucleus or group of two or three is a more deeply staining area which appears finely granular or granular and reticular. The rest of the membrane stretching between the nuclei and over the pore canals exhibits a fine reticular structure. The reticular structure is found everywhere, but is most distinct in the thin pore membranes. Discreet granules are absent or nearly absent in the epidermal sheet. It should be understood that the reticular appearance of the epidermal layer is perhaps only the optical expression of an alveolar structure. To demonstrate the reticular appearance a good immersion objective is necessary. I have chiefly used Zeiss 2 mm. ap. 1.30 but also Zeiss 2 mm. ap. 1.40, with comp. oculars 6 and 8. Very white clouds on sunny days afford satisfactory light.

*Results with other fixatives.*

Material mixed by other methods confirms the account just given.

*Picro-sulphuric.* Tangential sections and strips of epidermis were prepared from material fixed in picro-sulphuric. The staining was as for the alcoholic material and the preparations gave the same results. Absolutely no cell boundaries exist. The internuclear sheet more commonly appears finely granular rather than reticular. Possibly this is due to a deeper staining of the nodal points. But the fine reticular structure comes out well in places, especially in the pore membranes. Discrete granules such as are found in mesenchyme cells are either entirely absent or are found only in very small number here and there.

*Acetic acid.* Pieces were fixed in glacial acetic for a few minutes (5-10) and then transferred to water. The dermal membrane was peeled and cut from the choanosome, and was then cleaned of the underlying sponge parenchyma which was picked away with forceps and needles. The pieces were then stained, some in methyl green, others in acetic carmine or in haemalum, and were mounted in glycerine. Preparations so made give results similar to the foregoing. But they are not as transparent as balsam preparations and do not disclose the detailed structure of the internuclear sheet.

*Osmic acid.* Pieces were fixed in one-half per cent osmic for (10-15) minutes, washed in running water, and hardened in Müller's fluid 12 hours. They were run up very gradually through the alcohols. Sections and strips were made, stained in haemalum, and mounted in balsam. The preparations very frequently exhibited interesting artefacts. At first sight an epithelium seemed to be marked out in the clearest way. Perfectly clear channels of considerable width cut up the surface layer into areas that were often polygonal. Examination with an immersion objective showed that these areas were not cells. They sometimes have nuclei and sometimes not, and the channels between the areas exhibit peculiarities in their course which clearly indicate them to be cracks. The whole appearance must be due to the cracking of the very delicate epidermal sheet. The fixative probably makes the sheet brittle, and it later cracks perhaps during the washing.

*Sublimate.* Pieces were fixed for a few minutes in saturated corrosive sublimate and washed in iodised 70 per cent alcohol in the usual way. Tangential sections and strips of epidermis were prepared and stained in haemalum and congo red. Such preparations frequently exhibit artefacts similar to those produced by osmic. The surface layer is broken up into thin and irregularly polygonal pieces that are widely separated by perfectly clear channels. The latter are crossed in some places by a few slender protoplasmic filaments. Careful examination shows that the pieces are certainly not cells. Some are without nuclei, others with a nucleus or sometimes with two. They often include one or more large clear vacuole-like spaces. This appearance again is probably due to cracking of the epidermal layer, perhaps coupled with a violent coagulation set up by the sublimate. The appearance is certainly an artefact, although the pieces in many places look at first sight like cells.

*Silver nitrate.* Thin pieces were sliced off from the surface of a living sponge, and were fixed 5-10 minutes in one-twentieth per cent osmic acid. After thorough washing in distilled water, they were transfered to one per cent silver nitrate and exposed to direct sunlight 5-10 minutes (Hertwig's method). After washing and running up through the alcohols, strips of epidermis were peeled off and mounted in balsam. Tangenital sections were also made and mounted in balsam. As a control small hydromedusae were stained in the same way. The subumbrellar surface of the latter showed the usual polygonal network of distinct brown lines, marking out the epithelium cells. The method was employed several times on favorable days.

Stained in this way the surface of Stylotella frequently exhibits no lines that in any way suggest cell boundaries. But in places an appearance is got with a Zeiss D objective as if epithelium cells were marked out. Examination with an immersion objective shows that the appearance (fig. 4) is due to artefacts and not to the presence of epithelium cells. The facts may be summed up as follows. The network of lines is below the thin surface layer. The lines are no browner than other strands, viz., have the osmic and not the silver stain. In the meshes are irregular masses that are usually nucleated. The areas marked out by the lines may vary greatly in size. It is plain that such areas cannot be epithelium cells The appearance is probably caused by violent coagulation of mesenchyme cells and strands. Inter-cellular connectives and parts of cell bodies remain as the network of brown strands, while the cell bodies, contracted and torn loose from the connectives, remain as the irregular masses that lie in the meshes.

## REGENERATION OF THE EPIDERMIS IN STYLOTELLA

A dermal membrane with normal epidermis soon regenerates over a cut surface. For the study of the process of regeneration, sections vertical to the surface are of little use. The method I have followed was to allow the regeneration to proceed a certain time, then to fix and harden the piece of sponge, and to cut from the superficial region a number of thick (100$\mu$) tangential sections. For the fixation alcohol, picro-sulphuric and sublimate were employed. The piece was stained in toto with haemalum, and the sections with congo red. Paraffine and celloidin sections were chiefly used, but good preparations were sometimes made by slicing off free-hand the regenerating surface from the piece in alcohol, and at once staining and mounting the slices. Or the piece was fixed in glacial acetic, washed in water, and the regenerating surface sliced off. The sponge parenchyma was then picked away with needles and forceps from the surface layer, which was later stained and mounted in glycerine.

The original cut surface was made as smooth as possible, and all of it is included in the first few sections. These are mounted with the regenerating surface uppermost. Where the surface was part of the choanosome such preparations are too opaque for study. But where the surface was part of the transparent collenchyma, the sections offer fairly clear pictures. Much the best pictures of all are to be had from the new dermal membrane which develops across the cut ends of the larger canals. To obtain membrane of this kind I cut off oscular lobes about an inch below the apex, thus cutting the main efferent canals transversely. The open ends of the canals become closed in by the new membrane which extends out from the surrounding collenchyma across the aperture. The rate at which the canals become c'osed in may be gathered from the following record. The lobes were cut off at 9:30 a. m., the cut surface of each lobe showing several widely open canals. At 1:30 p. m., most of the canals weie closed in by thin, collenchymatous membranes perforated in the center, like diaphragms. In the case of a few canals the membranes had completely closed the apertures. Within an hour or two all of the membranes had completely formed and the canals were entirely closed in. In fig. 5 one of the newly formed membranes, *c. m.*, with surrounding collenchyma and outlying choanosome is shown.

When the cut is first made, the dermal membrane covering the rest of the sponge ends at the exposed surface with a sharp edge. On the cut surface itself are exposed in choanosomal regions, flagellated chambers, mesenchyme, and spicules; in the regions immediately round the larger canals, only collenchymatous mesenchyme. The mesenchyme everywhere includes branched cells freely interconnected, and free amoebocytes. The latter are scarce in the collenchyma. Collenchymatous mesenchyme is especially characterized, it will be remembered, by the large amount of watery intercellular substance and the considerable length of the cell processes. A recognisable new dermal membrane develops over the whole surface within a day. The edge of the old membrane remains distinguishable for some hours, but it applies itself closely to the more solid sponge tissue, sinking in to meet the latter where it had covered subdermal spaces, and after about 12 hours it is no longer recognisable. By this time it is in perfect continuity with the layers of mesenchyme cells stretching over the cut surface and which are developing into the new dermal membrane.

We may now proceed to the detailed examination, by stages, of the developing dermal membrane and epidermis, using for study as explained above the membranes that develop across the open ends of canals and over collenchymatous regions.

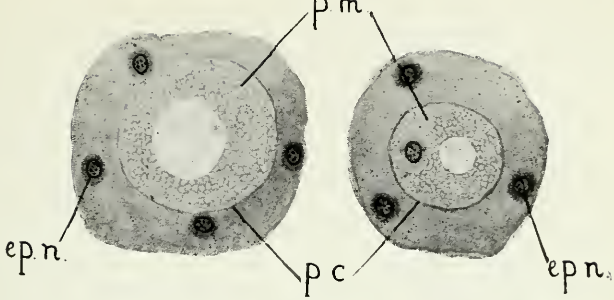
*One hour after cutting.* The cut surface is occupied by branched cells containing abundant and conspicuous granules. Even in a comparatively small area they exhibit slight differences of level. These cells are interconnected so as to form a fairly close network. Some very small spheroidal cells, probably metamorphosed collar cells, lie free here and there. Many of the superficial granular cells are thin and flattened. Below the superficial cells lie several layers of essentially similar granular cells which are not flattened. They are interconnected with one another and with the superficial cells. The entire network formed by the granular mesenchymal cells is closest at the cut surface and becomes more and open as we go deeper below the surface.

*Two hours after cutting.* The cells at the surface are now more uniformly flattened than they were an hour earlier. A group of the superficial cells is shown in fig. 6.

*Five hours after Cutting.* The surface is now occupied by a layer of thin, flattened, coarsely granular cells or cell areas connected by a complex network of fine intercellular strands (fig. 7). The cells areas are mostly uninucleate but may include two or even three nuclei. The areas have no precise boundaries but merge gradually into the intercellular network. On focussing below the surface layer, coarsely granular mesenchymal cells come into the view. These have slender processes and are freely interconnected forming a coarse open network (fig. 8, *m. c.*) This open network of coarsely granular mesenchymal cells constitutes the body of the developing dermal membrane. In it spaces which doubtless represent pore canals have already appeared. One such is shown in fig. 8 (*p. c.*) The mesenchyme cells bounding it, and which doubtless become the lining epithelium, do not yet form a continuous wall. Above the developing pore canal the epidermal layer, *p. m.*, is shown as it appears at the upper focus.

*Twelve hours after cutting.* The surface is now occupied by a continuous epidermal membrane in which the cells that have fused are still distinguishable (fig. 9). The area around each nucleus or group of two or three takes a deeper stain and appears as a finely granular, vaguely delimited area containing a good many of the coarse granules that characterise the fusing cells in earlier stages. Between these areas the epidermal membrane is a thin continuous sheet which in places appears reticular (alveolar] and in other places more fibrillar. In this thin sheet one sees here and there a few of the coarse granules which seem to be lodged, in cases at least, at the nodes of the reticulum. The sheet exhibits small perforations of varying size, sometimes twice as large as that shown in fig. 9 (*per.*) Possibly these are the beginnings of pores, although I was not able to observe that they always lay

PLATE II.

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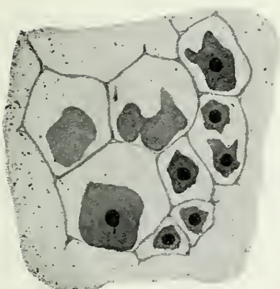

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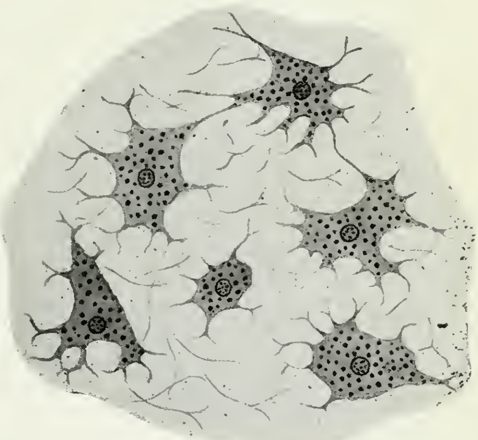

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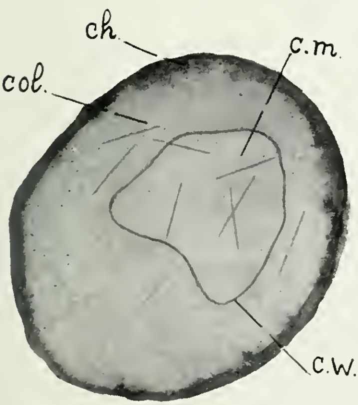


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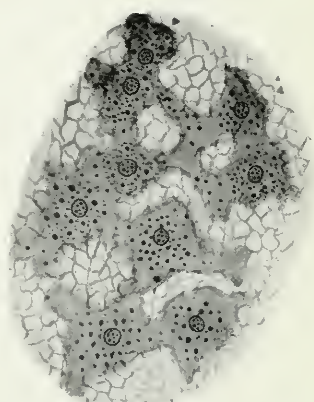

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over pore canals. In a regenerating dermal membrane at this stage groups of well formed pore canals are found here and there (fig. 9, *p. c.*) In the preparation shown in fig. 9, the pores are open.

*Later development.* The epidermis 24 hours after cutting is like that of the normal sponge. The course granules found in earlier stages are absent or present only in scanty number here and there. Pore canals that are open or closed in by pore membranes are abundantly present. The ectosomal skeleton is scanty. Pieces of sponge were kept in live boxes for a week and in these examination indicated that the ectosomal skeleton was practically like that of the normal sponge. The color of the new surface at this time was still like that of the interior, orange, while the old surface was orange with a distinct tinge of green.

*Summary.* A comparison of the stages just described shows that immediately after the cutting coarsely granular mesenchyme cells approach the exposed surface in considerable number. Many of the migrating cells are doubtless originally free amoebocytes. The granular cells when they have reached the neighborhood of the surface appear as branched bodies freely interconnected. This layer of interconnected granular cells develops into the new dermal membrane. The cells at the surface become flattened and more closely set than the deeper elements from which they are no doubt recruited during the first few hours The fuse to form the epidermis. Union between the cells takes place not through crowding so as to give rise to plane surfaces, but through the continued development of intercellular connectives. As these become more numerous and branched they give rise to a complex reticulum of protoplasmic strands. This intercellular reticulum becomes transformed into what we would usually speak of as a continuous sheet of protoplasm, although careful examination shows that even in the adult it has a finely reticular, possibly alveolar structure. During the metamorphosis of the superficial granular cells into the epidermis, the cells loose their characteristic granules. The pore canals arise as excavations in the mesenchyme of the developing dermal membrane, and are covered in by the new epidermis which in such places constitutes pore membranes.

## THE EPIDERMIS IN RENIERA

The species used is an undescribed one fairly common in Beaufort harbor. The body, frequently about 100 mm. high, is a complex system of anastomosing cylindrical branches, the diameter of which varies from 3 mm. to 8 mm. The color is often pink but varies to a brown. The oscula terminate short tubes arising vertically from the branches. Such oscular tubes are frequently 1.5–3 mm. in diameter, 2–4 mm. high. The wall of the tube is colorless, thin, and transparent. The sponge, like the other two forms used for the observations recorded in this paper, falls in the halichondrine monaxonida.

For the study of the epidermis pieces were fixed in absolute alcohol, 95 per cent alcohol, sublimate, picro-sulphuric. Thick tangential sections were made from the smoothest and most transparent parts of the surface. Both celloidin and paraffine were employed. Useful preparations were also made directly from the oscular tubes in the following way: The tube was cut off, split lengthwise, the sponge tissue picked away from the canalar surface, and the pieces mounted with the epidermal surface uppermost. For staining I made use in general of haemalum and congo red, staining the piece in toto with haemalum and the sections in congo.

*Results with material fixed in alcohol*

Alcohol proved much the best fixative. The epidermis is so delicate a membrane that during the treatment necessary with other fixatives it cracks. In the alcoholic preparations clean places must be looked for. These are abundant enough, and in such places the structure of the layer may be successfully studied. There are no cell boundaries. The layer is a syncytium as in Stylotella, consisting of a thin, continuous sheet of protoplasm containing abundant nuclei that are irregularly scattered (fig. 11). Round each nucleus as a rule the protoplasmic sheet is thicker than elsewhere, takes a deeper stain, and presents a finely granular appearance. The rest of the sheet is minutely reticular. Granules sufficiently large to be recognised individually and which are abundantly present in mesenchyme cells, are not found in the epidermis

The recticular character of the sheet is very distinct in places where the staining is both deep and clean. The meshes appear to be actual spaces. They look clear and empty and are bounded by the stained reticular lines. The thin pore membranes closing in pore canals are especially favorable for such observations. The epidermal sheet is certainly of surprising delicacy and thinness. It may often be traced over the large spicules which lie horizontally and form the superficial meshes of the skeletal network. In such places it rests upon the white background of the spicule and the reticular character comes out distinctly. There are places where mesenchyme cells of the dermal membrane also lie on top of the superficial spicules. But it is where the epidermis alone crosses the spicule that the opportunity for study is so especially good.

*Results with other methods*

*Sublimate* was given a good trial as a fixative. The epidermis cracks a great deal. The fragments are sometimes fit for study. They exhibit the reticular character of the sheet and an absence of cell boundaries, as noted above.

*Picro-sulphuric* which is a good fixative for the epidermis in Stylotella does not give good results on Reniera. The epidermis cracks into pieces. When treated with this fluid the membrane seems to have no stiffness. Thus it often drops down into the pore canals and breaks away from the part left on the surface. The fragments are sometimes fit for study. They are frequently polynucleate but exhibit no cell boundaries. The reticular character of the sheet could not be observed on this material.

Several trials of the silver nitrate method were made on favorable days. The silver entirely failed to show the presence of cell boundaries in the epidermis. Where the stain is deep, the outlines of mesenchyme cells and processes sometimes appear. The silver was used according to the method already described for Stylotella. Oscular tubes that had been so stained were split and mounted in water, glycerine, and balsam. Tangential sections were also made. As a control pieces of an expanded Leptogorgia were used, and the epithelial cells on the surface of the polyps were here outlined with great distinctness.

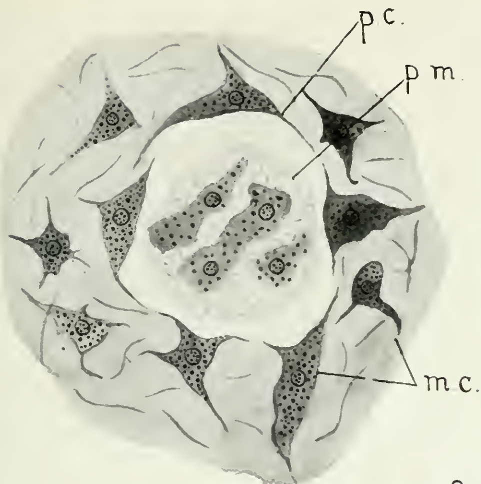
*Pores, pore canals, and pore membranes*

In the preparations made from preserved material, the pores are sometimes wide open or partially, sometimes completely, closed by pore membranes. The pore membrane as in Stylotella is simply an extension of the epidermis. When it incompletely closes the pore it has a single nucleus (fig. 11), and even when it is complete it may have but one (fig. 11). Frequently, however, when it is complete it exhibits more than one nucleus (fig. 11, *b*). As long as the pore membrane is imperfect the outline of the pore canal is distinct. When the pores are completely closed, however, it often happens that the outline of the pore canal is vague or lacking at some part of the circumference (fig. 11). The explanation of this appearance must be that after the epidermis has extended over the pore canal the mesenchyme of the dermal membrane also extends in towards the middle of the canal, thus tending to obliterate it.

Fortunately in this sponge the behavior of the pores may easily be watched during life. For this purpose an oscular tube is cut off, split lengthwise, and the halves mounted with epidermal surface uppermost in plenty of sea water under a coverglass. The cover flattens the pieces sufficiently to permit the use of a one-sixth inch objective. In such preparations made from a sponge just removed from the live box, many of the pores will be found open and their closure may be actually observed. I append the following records of observations on the closure of selected pores.

*Pore 1.* At 9.45 a. m., the pore is open with one nucleus at the margin (fig. 10). The nucleus shifts its position, traveling back and forth along the margin, going sometimes half round the pore and back again. The movements of the nucleus are quick and easily observed. At 9.50 the epidermis extends a short distance over the margin in the shape of a thin film. This gradually spreads across the pore becoming a well marked pore membrane. As it spreads the originally marginal nucleus passes into it. The sketches (fig. 10) show successive stages in the passage of the

PLATE III.

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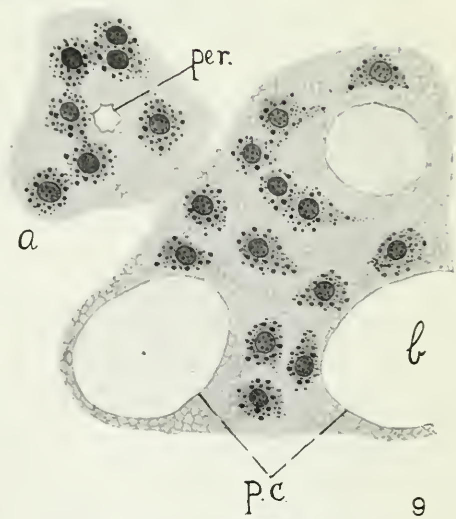


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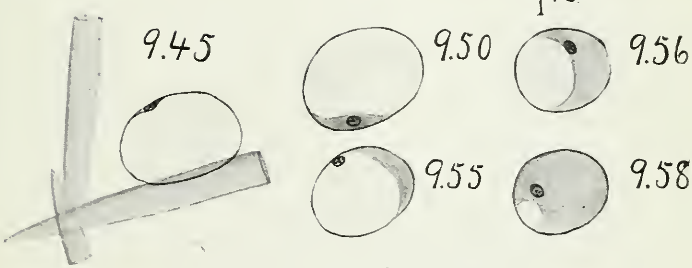


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membrane across the pore. At 9.58 the pore canal is almost completely closed in. Its outline is still distinct at this time. Five minutes later the pore is completely closed, and the outline of the pore canal is no longer distinguishable.

*Pore 2.* The pore at 10 a. m., is partly closed by a few interconnected strands of protoplasm which include a nucleus (fig. 12). The strands are thin and delicate, and are in continuity with the surrounding epidermis. The protoplasmic strands change form and arrangement, and the nucleus shifts its position, all very quickly. Such amoeboid movements continue for some minutes. During their progress camera sketches were made, and the conditions at 10.05 and 10.07 are shown in fig. 12. By 10.10 the protoplasmic strands have taken the shape of a marginal film. This is drawn into the epidermis, the nucleus remaining at the margin of the pore, and at 10.12 there is only the usual appearance of an an open pore. The nucleus now shifts quickly back and forth along the margin of the pore, narrow marginal films appearing and disappearing as the nucleus changes position (comp. sketches drawn at 10.15, 10.17, 10.20, fig. 12). The narrow marginal film present at 10.20 begins to spread at 10.21 and rapidly covers the whole pore, becoming a pore membrane into which the nucleus passes. Two stages in the completion of the pore membrane are drawn as they appear at 10.23 and 10.25. The pore is completely closed by 10.27. The wall of the pore canal was distinct all round until 10.21. Shortly after that time it began to grow indistinct round a part of the circumference (right side). At 10.25 it was no longer distinguishable in this region and was only vaguely outlined on the opposite side. The pore canal was kept under observation until 10.40 a. m. At that time its outline (*p. c.* in fig. 13) was still vaguely distinguishable, although circumscribing a much smaller area than formerly.

*Pore 3.* When the observations began the pore canal (fig. 14, 1.45 p. m.) was far smaller than the normal. It had evidently already contracted. It was partly covered by a pore membrane at the margin of which lay a nucleus. The marginal pore membrane was then largely drawn into the epidermis, the nucleus shifting its position in what remained (comp. sketches drawn at 1.50 and 1.53). At 1.53 the marginal membrane began to spread rapidly, closing in the pore by 1.57. After complete closure of the pore the outline of the pore canal was still distinguishable. The outline was distinguishable but smaller at 2 p. m. The wall at this time was far from sharp and appeared rough and granular, whereas before closure of the pore it was sharp and smooth. The rough outline at 2 p. m., probably indicates how far the mesenchymal jelly has spread towards the middle of the original pore canal.

*Pore 4*. The pore at 2.05 p. m., was wide open, and at the margin two nuclei were distinguishable (fig. 15, 2.05 p. m.) One nucleus, *a*, remains at rest, but the other nucleus, *b*, shifts its position back and forth in the usual way. It position at successive moments is shown in the camera sketches made at 2.07 and 2.10. Nucleus *b* is the pore nucleus, the movements of which are associated with the formation of the pore membrane. The other nucleus *a* is not especially concerned in the closure of the pore. At 2.12 the epidermis has just crept beyond the margin of the pore, carrying with it the nucleus *b*. By 2.15 the pore membrane has completely crossed the pore and the outline of the pore canal is indistinguishable.

*Pore 5*. At the beginning of the observations (fig. 16, 3.15 p. m.) the pore which is somewhat constricted is crossed by a single strand of protoplasm. The strand moves across the pore and incorporates the nucleus (3.20). The strand with the nucleus at its base now shifts its position across the pore back and forth, finally passing to the edge and becoming a marginal film (3.30). This quickly spreads over the pore in the usual way.

*Pseudopodial activity at the pores*

While making observations on the closure of pores, pseudopodial activity was occasionally observed at the margin of the pore and at the free margin of a partial pore membrane. In fig. 17 three pores are represented in which such activity is going on. In pore *b* the pseudopodia extend out from the incomplete pore membrane, in the other two cases from the margin of the pore itself. The fine pseudopodia were thrown out, moved about quickly, often fused more or less with one another, sometimes combining to form a network (pore *c*). They then were partially or completely drawn in, but reappeared after a short interval. This remarkable phenomenon was observed in the case of the three pores shown during one-half hour, at the end of which period the pores were still wide open and the pseudopodial activity going on. At several other times I have noticed the formation of one or two flagellum-like pseudopods at the margin of open pores. Such pseudopods would quickly appear, move or wave from side to side, and be drawn in. There was nothing to indicate that this pseudopodial activity at the margin of pores was a pathological phenomenon. It is possible that it occurs commonly during life. and that the pseudopodia are temporary, sensory processes which explore, so to speak, the region of the open aperture. The facts afford a further illustration of the widespread occurrence of "filose phenomena," to the importance of which as an expression of the fundamental nature of protoplasm, Professor and Mrs. E. A. Andrews have repeatedly called attention (see especially, Andrews G. F., '97).

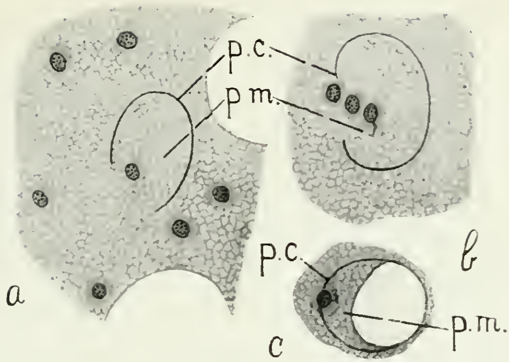
*Summary account of pore closure in Reniera*

The pore canals may undoubtedly contract, viz., while still open become smaller (comp. figs. 15 and 16). The entire thickness of the dermal membrane shares in this process. Actual closure is, however, brought about by an extension of the epidermal layer across the pore. This extension of the epidermis may at once constitute a simple and continuous pore membrane (fig. 10) similar to that present in Stylotella. Or the epidermis may first extend across the pore in the shape of one or more strands of protoplasm which shift about in amoeboid fashion (figs. 12 and 16) and are then withdrawn into the general layer before the continuous pore membrane finally begins to extend across the pore. A single nucleus not differing in appearance from other epidermal nuclei is associated with the closure of a pore. It lies at the margin round which it is shifted back and forth, in the first stage of closure, probably by wave-like movements of the protoplasm similar in some respects to those occurring in plant cells (Nitella, *e. g.*) These movements of the nucleus are quick and easily observed. For instance a nucleus made the complete circuit of a widely open pore in about one minute. After closure of the pore, other nuclei beside the pore nucleus may pass into the area which covers the pore canal (fig. 11). The constant presence of a nucleus at the pore and its quick changes of position strongly suggest that it is in some way physiologically concerned in pore closure.

The extension of the epidermis to form a pore membrane does not necessarily involve the rest of the dermal membrane, and hence after the epidermis has spread across the pore, the pore canal may still remain open, in which case its outline is distinguishable on focussing below the surface. Usually after closure of the pore. the outline of the canal is suddenly lost to view. This must be due to centripetal streaming of the mesenchyme of the dermal membrane, induced by some local contraction in the epithelial wall of the canal. Perhaps in nature the pores commonly remain in this condition until they reopen. At any rate this is the state in which closed pores are usually found in preserved material (fig. 11). In excised pieces of sponge kept under a cover glass the pore canal may completely or almost completely disappear. In this latter case the area of the canal diminishes greatly in size and its outline becomes rough and vague (figs. 13 and 14). This small and vaguely outlined area represents the central region of a pore membrane, and indicates how far the mesenchyme of the dermal membrane has streamed inwards in its obliteration of the pore canal.

The formation of a pore membrane is a contraction phenomenon which involves only the epidermis. The closure of the pore canal is probably also primarily a contraction phenomenon, which in this case involves the epithelial lining of the pore canal. The epithelial lining contracts, we may suppose, after the fashion of a sphincter, locally or throughout the extent of the pore canal, and so tends to obliterate the lumen. Such contraction brings with it a centripetal streaming of the mesenchyme of the dermal membrane. The closure of the canal is certainly not brought about by

## PLATE IV.

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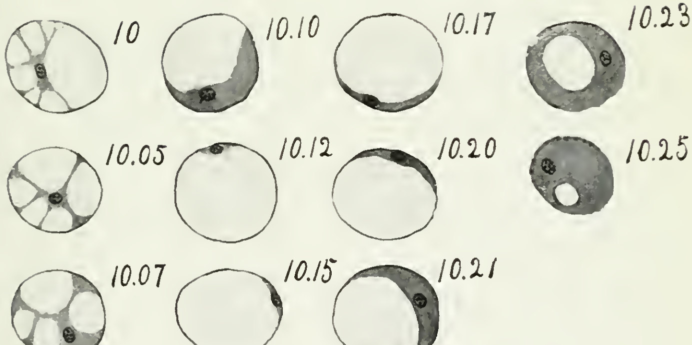


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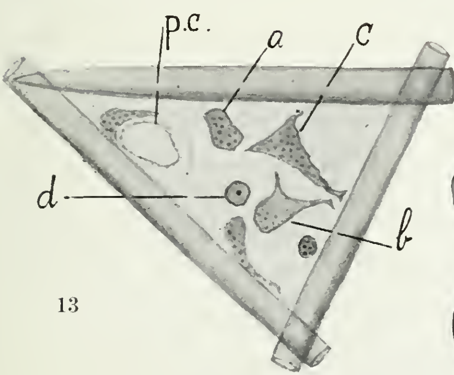


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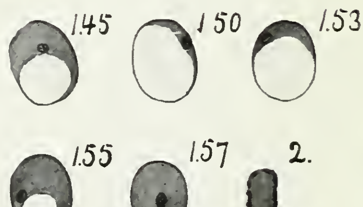


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the contraction of surrounding fibre-like cells arranged in sphincter fashion. There are none of these.

In the centripetal streaming of the dermal mesenchyme we must distinguish active movements of cells and passive movements of intercellular jelly. Both undoubtedly occur. On the active movements of such cells I may record the following few observations. The conspicuous cells in the mesenchyme of the dermal membrane are coarsely granular amoebocytes (cells *a*, *c*, in fig. 13) and pale cells either without coarse granules or with only a few (cells *d*, *b*, in fig 13). Both varieties of cells may appear in the spheroidal shape. When they are actively moving they are irregular in shape, the body extending out into slender prolongations. Cells of both varieties constantly shift their position, and undergo changes of form, all very slowly. The granular amoebocytes move more actively than the pale cells. The cells *a* and *c* crossed the space included between the spicules, passing over *b* which they obscured for a time. In crossing the space, cell *a* consumed five minutes.

## CLOSURE OF PORES IN LISSOCENDORYX

The species used was Lissodendoryx carolinensis, a common form in Beaufort harbor, and a description of which is contained in a paper now in press for the U. S. Bureau of Fisheries. The sponge falls in the halichondrine monaxonida. The whole surface is abundantly covered with tubular translucent papillae the walls of which are perforated with numerous pores. These pore-papillae which are often slightly branched are contractile and may almost entirely disappear. When dilated they are about 3-5 mm. long and 1 mm. in diameter.

If such pore-papillae in the expanded state are cut off and mounted in sea water, many pores are found to be open, and their closure may be watched under the microscope. Each pore lies in a field surrounded by long spicules (tylotes) and when expanded is large. As in the cases of the preceding species, I restrict the term pore to the actual aperture of the surface, using the term pore canal for the very short tube which perforates the wall of the pore-papilla. I append the following record of observations on the closure of selected pores.

*Pore 1.* When the observations began at 2.25 p. m., the pore canal and pore were wide open. The pore canal steadily contracts until 3.20 p. m. The diameter of the canal at this time is about one-third of the original size. While the pore canal is contracting, the surrounding spicules come closer together (the whole papilla contracts). The mesenchyme cells at 3.20 extend to the very wall of the pore canal. Immediately after 3.20, a thin homogeneous looking membrane containing no mesenchyme elements suddenly extends out across the open aperture. This pore membrane (fig. 18, 3.25 p. m.) in a few minutes time closes the pore completely.

*Pore 2.* The pore canal at 3.30 p. m. had already contracted to about one-half the full size, and was in the same condition as pore 1 at 3.20 The pore, however, closes in a different way from pore 1. The canal steadily contracts until it disappears, at 3.40 p. m.

*Pore 3.* The pore canal contracts to about one-half its original diameter. It then is found covered in near its margin by an extension of the dermal membrane. This extension constitutes zone *b* of fig. 19. From this zone a further extension in the shape of a very thin membrane, zone *a*, formed exclusively by the epidermis, extends over the more central part of the canal. It seems proper to designate zone *a* as a pore membrane. My record for this pore is not complete. Probably the pore membrane was first formed, and the mesenchyme of the dermal membrane later streamed inwards, forming zone *b*. The pore membrane soon closes the pore completely. The distinction between zones *b* and *a* is later lost, since granular amoebocytes and microscleres invade zone *a*. Even after this has occurred, on focussing below the surface, the wall of the pore canal may be seen.

*Summary.* In this sponge the pores do not always close in the same way. (1) Often the whole pore canal closes up and disappears by simple contraction. Pore 2 closes in this way. (2) In other cases the pore canal shrinks as before, but actual closure is brought about by a rapid extension of the epidermal layer across the pore, forming a pore membrane (pore 1.) (3) In still other cases the pore canal shrinks and closure is then effected through the formation of a pore membrane which is gradually reinforced by the dermal mesenchyme (pore 3).

## COMPARISON OF THE METHODS OF PORE CLOSURE AS OBSERVED IN STYLOTELLA, RENIERA AND LISSODENDORYX

The various ways in which pores were observed to close in the three species of sponges that were studied may be arranged in a series expressing the successive physiological states that conceivably may occur in the closure of a dermal pore in monaxonid sponges generally. (1) A partial closure of the pore may be brought about by the extension of the epidermis across the aperure in the shape of one or more amoeboid strands of protoplasm (figs. 12 earlier stages, and 16, for Reniera). Possibly this state is sometimes preceded by the formation of fine pseudopodia at the margin of the pore (fig. 17, for Reniera). Such closure is temporary. The pore opens and then remains open or (2) is completely closed by a continuous extension of the epidermis across it, forming a pore membrane (fig. 12 later stages, for Reniera; figs 2 and 3 for Stylotella). (3) To bring about a more secure closure of the pore, the pore membrane is reinforced by a centripetal extension of the dermal mesenchyme induced through contraction of the epithelial lining of the pore canal. This reinforcement extends gradually from the margin across the whole pore (fig. 19 and pore 3, for Lissodendoryx). (4) Hitherto the lower part of the pore canal, opening into the subdermal chamber, has remained open. Contraction accompanied by centripetal streaming of the dermal mesenchyme now affects this part of the canal and almost obliterates it (fig. 13, for Reniera) or completely obliterates it (pores 1 and 4, for Reniera).

The final result, complete closure and obliteration of the pore canal, which may occur as the end of a series of easily distinguished steps, is in other cases brought about simply through continued shrinking (pore 2, for Lissodendoryx). Or the pore canal may shrink greatly, and then be closed in by the formation of a pore membrane (fig. 18, for Lissodendoryx,) the complete obliteration occurring later.

## THE CANAL EPITHELIUM IN STYLOTELLA

Oscular lobes of sponges in which the canals were well expanded, were fixed in alcohol (absolute and 95 per cent,) sublimate, and picro-sulphuric. After hardening pieces were excised which included two or three of the main efferent canals, and these were sectioned so as to cut the canals longitudinally. Celloidin was used as an imbedding material, and the sections were cut thick. As the series of sections passes through a canal, the first and last sections will of course cut the canal wall tangentially, and these sections when mounted with the canalar face up give excellent surface views of the lining. For staining haemalum was used "in toto," and the sections were stained in congo red. It is only the main efferent canals that I have studied.

Pieces fixed in alcohol and picro-sulphuric yield essentially the same results. A study of the details show further that the results are reliable. The main efferent canals are lined with the epithelial membrane depicted in fig. 20. It may be seen that the membrane consists of a single layer of flattened cells that are separated by wide spaces across which abundant intercellular connectives pass. The cells are in general elongated in a direction transverse to the long axis of the canal, but polygonal cells also occur. The cytoplasm is granular and vacuolated, and quite without distinct boundaries. It passes insensibly into the intercellular connectives. The vacuoles vary in size and are irregularly distributed. In many cells the granules are scattered more or less uniformly through the cell, but quite commonly they are distributed in dense and pretty straight tracts which often extend along one margin. The nuclei appear to be all alike. They uniformly show the membrane, nucleoplasm, and chromatin in the shape of granules or short pieces (doubtless a reticulum exists).

The term "cell" and the idea expressed by it are not altogether appropriate to the nucleated areas present in this membrane. The areas are everywhere united by abundant intercellular connectives, and merge very gradually into these, the cytoplasm often thinning away into reticulated films which then pass into the intercellular strands. Where the margin of the cell area is densely granular, the distinction between cell and the connective is sharper (a figure inevitably represents the contrast between cell body and connective as sharper than it exists in nature). The nucleated areas are frequently directly confluent, so that one and the same area may contain two nuclei (fig. 20). The membrane is actually of course a syncytium, but it is one in which the component cells permanently remain in a state of imperfect union. The regenerating epidermis passes through an essentially similar stage (fig. 7). The canal lining thus remains in a condition not so far removed from the mesenchyme as is the epidermis. Like the epidermis it may be regenerated from the mesenchyme, probably as Weltner ('07) maintains, largely from the granular amoebocytes.

When the membrane is examined with a comparatively low power, the nucleated cell areas appear to have distinct boundaries and to be independent cells separated by wide spaces. Fixation with sublimate may lead to the same erroneous conclusion. In fig. 21 the canal epithelium is represented as it appears when prepared from sublimate material. The cells are widely separated and have good sharp boundaries. The cytoplasm is finely granular and fairly dense. Almost no intercellular connectives are present. The absence of the connectives and the uniform dense granular appearance of the cells when comparison is made with a good alcoholic preparation such as that from which fig. 20 was made, must be regarded as artefacts due to the sublimate treatment.

There is good indication that the lining epithelial cells are contractile and of themselves bring about the diminution in bore of the canal. The canals certainly do diminish in bore, and greatly at times. Round the canal there are no fibre-like mesenchyme cells arranged sphincter fashion. But the shape and arrangement of the lining epithelial cells suggests plainly that they are the closers of the canal. As I have said the cells lining an expanded canal are in general elongated transversely to the long axis of the canal. Very often the cell is so long and narrow that it is properly described as fibre-like (figs. 20 and 21). Mingled with such one finds other cells that are not greatly elongated and still others that are polygonal (fig. 21). I have examined some canals in which contraction had very materially diminished the size of the lumen. In these I found that a very large number of cells were either only moderately elongated or were polygonal. This is what one would expect to find if the epithelial cells do by contraction shorten and so tend to close up the canal.

In this connection it may be noted that in the case of contracted canals, when seen in cross section, the surrounding mesenchyme (collenchyma) cells are found to be greatly elongated and arranged in such fashion that they radiate outwards from the canal wall. The appearances suggest that as the epithelial cells are the closers of the canal, the surrounding collenchymal cells act as openers.

## COMPARISON

It is well known that in a large number of sponges the dermal surface is covered and the canals lined with a single layer of cells (pinacocytes of Sollas) forming an epithelium. It was F. E. Schulze who in 1875 first established this fact. After demonstrating the presence of epithelia in Sycandra he showed in succeeding numbers of his classical "Untersuchungen" that the same or very similar structural conditions are found in a great variety of sponges. Schulze's conclusions have been confirmed and extended, for the same and other forms, by many observers. A review of the literature shows, however, that both Schulze and other observers have now and then, in this sponge or that, been unable to demonstrate the presence of distinct cells in the epidermal membrane. Possibly in some of these forms the epidermis is a continuous syncytium as in Stylotella and Reniera. With regard to the canal lining a number of recorded facts suggest that loose epithelioid membranes such as I have found in Stylotella perhaps occur with some frequency in place of typical epithelia composed of polygonal cells fitting together neatly by straight edges. The covering layers of surfaces exposed to the water are certainly less uniform in sponges than was supposed some years ago to be the case. The hexactinellids in particular depart from the common condition. In these sponges, as Ijima's important discoveries seem to show, the covering layers in question can not be regarded as epithelia at all.

In the following sponges the occurrence of epithelia on the surface of the body, or lining the canals, or in both situations, is well established.

*Calcarea.* In Sycandra (Schulze '75) the dermal and gastral surfaces are covered with an epithelium composed of a single layer of flat polygonal cells which fit together neatly. In Grantia according to Dendy ('91 a) the epidermis is a simple flat epithelium and the inhalent canal system is lined with a similar layer. In Vosmaeropsis too, Dendy ('93) finds that the epidermis and canalar lining are simple flat epithelia. In Clathrina, Minchin ('00) finds the dermal surface covered with flat polygonal epithelium cells, between which are intercalated the peculiar pore cells. In Leucosolenia, Dendy ('91 b) finds the dermal surface covered with thin flat po'ygonal epithelium cells. The more recent investigations of Urban ('06) show that while the flat cell is the common type, the epidermis also includes cells of other shapes, some cylindrical, some flask-shaped, the later probably glandular. Minchin '08 confirms Urban's account as to the variation in shape of the epidermal cells in this genus.

*Carnosa.* In Chondrosia and Chondrilla (Schulze '77b) the canals are lined with a simple flat epithelium. In Plakina (Schulze '80) the dermal surface and canals are covered with a single layer of flat epithelium cells that are flagellated. In Plakortis (Schulze, loc. cit.) the conditions are similar except that the cells are probably not flagellated. In Corticium, Schulze ('81) finds that the dermal surface is covered with flat epithelium cells. The canals of this genus are lined in places, according to Lendenfeld ('94, p. 71) with columnar epithelium.

*Tetractinellida.* In Craniella and some others of the "Challenger" tetractinellids Sollas was able to distinguish epithelial cells. He does not state whether the cells in these cases were epidermal or canalar ('88, p. 36.) In Geodia and Ancorina Lendenfeld finds ['94, p. 74] that the canals are lined in places with massive cells.

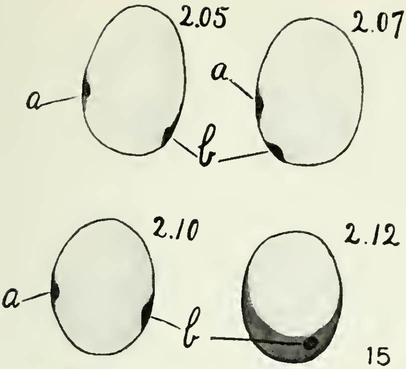
*Monaxonida*. Among the Clavulina Lendenfeld finds ('96) in Tethya, Suberites, and Polymastia that the epidermis consists of flat epithelium cells. In Vioa, Suberanthus, Astromimus, and Papillella he finds the canals lined with epithelium cells which in some cases are flat, in others high, the two varieties perhaps only representing different physiological states of the same elements. In Suberites, Thomson ('86) observed that the epidermis consisted of a single layer of small, polygonal, and apparently unequal cells. Among the halichondrine monaxonida the Spongillidae are perhaps the best known. In these sponges (Ephydatia) Weltner ('96, '07) finds the epidermis and canal lining made up of flat epithelium cells (pinacocytes). Delage and Hérouard describe (99, p. 176) the same condition as obtaining in Spongilla. According to Weltner the epidermal cells include the pores which would therefore be intracellular.

*Keratosa*. In Aplysina (Schulze '78 a) the dermal surface and canals are covered with flat epithelium cells. In Spongelia (Schulze '78 b) the same condition occurs. In Euspongia and Hircinia (Schulze '79 a, b) the canals are lined with flat epithelium. In Aplysilla (Schulze '78 a, Lendenfeld '89) the epidermis and canalar lining are made up of flat cells. In Dendrilla and Halme Lendenfeld ('89) finds that epidermis and canalar lining are made up of flat epithelium cells that are flagellate. In Ianthella (Lendenfeld '89) the epidermis consists of flat cells.

*Myxospongida*. In Oscarella lobularis (Schulze '77 a) the dermal surface is covered wlth a single layer of fairly thick cells that are flagellate, and the canals are lined with a similar layer. In Halisarca Dujardini (Schulze '77 a) the canals are lined with flat simple epithelium.

*In the Hexactinellida* true epithelia appear not to be present either on the surface or lining the canals. A thin nucleated protoplasmic layer, to be sure, has been known since F. E. Schulze's examination of the "Challenger" collections ('87) to occur on the

PLATE V.

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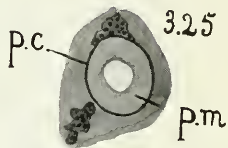


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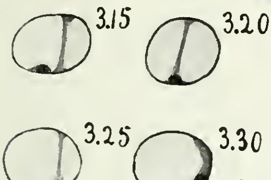


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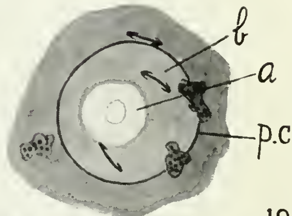


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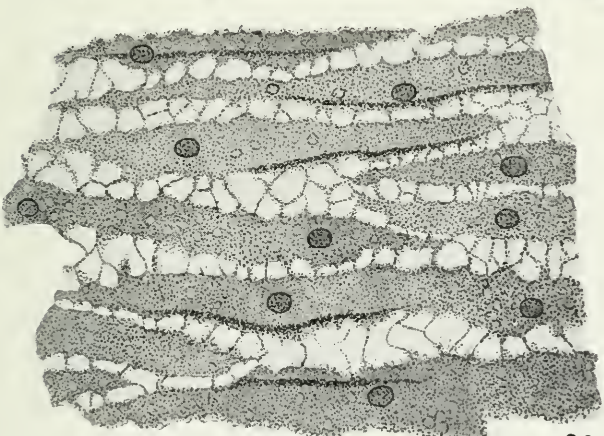

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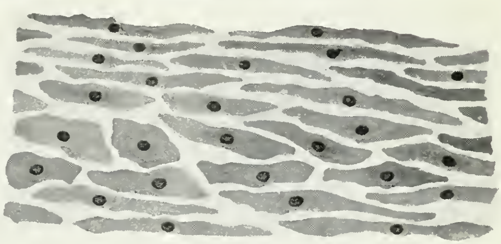

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dermal and canalar surfaces in many of these sponges. Schulze regarded the layer as an epithelium, stating however, that he was not able to detect the contours of the cells. Ijima ('01, '04) finds that such membranes do not consist of differentiated epithelial cells distinct from the underlying trabecular tissue (essentially a plexus-like syncytium of mesenchyme elements), but are produced simply by the flattening out of the superficial trabeculae. In some cases there is really no bounding membrane, since the general syncytium preserves at the surface its character as a reticulum. Schulze is inclined ('04, p. 202) to assent to Ijima's position and remarks "Es ist also wohl anzunehmen dass hier" (in the hexactinellids) "die Differenzierung der oberflächlich liegenden Gewebszellen zu echten epithelialen Pinakocyten unterblieben ist." The permanent condition of a hexactinellid would thus seem not to be far removed from that of a monactinellid (Stylotella) which is in process of regenerating its epidermis. Rarely it may happen that monactinellids linger permanently at this low stage of histological development. Suberanthus as recorded by Lendenfield (96, p. 172) seems to be a case in point:

"Bei Suberanthus flavus ist die äusserste Gewebelage aus einer dichten, vielschichtigen Lage von unregelmässigen, massigen, multipolaren Zellen zusammengesetzed. Die äussersten von diesen sind auf der Aussenseite abgeflacht und bilden das äussere Epithel, unterschieden sich aber sonst in keiner Hinsicht von den tiefer liegenden."

In the following sponges the records leave it uncertain what is the structure of the epidermis. In Chondrosia and Chondrilla (Schulze '77, pp. 18, 20, 23, 27) an epithelium does not occur on the dermal surface, which is covered with a thin, finely fibrous or homogenous cuticular layer that is possibly formed by the fusion and metamorphosis of cells. In Euspongia (Schulze '79 a, p. 626) it is uncertain whether the epidermis is composed of distinct cells. In Hircinia (Schulze 79 b, p. 16) the structure of the epidermis is uncertain. Some observations would indicate the presence of distinct cells, others that no cell boundaries exist. In Halisarca Dujardini (Schulze '77 a, p. 38) the dermal surface is covered with a peculiar layer, cuticular in appearance, probably formed by fusion of epithelial cells that undergo a gelatinizing metamorphosis.

*The case of Reniera.* In Reniera aquaeductus Metschnikoff ('76) thought that he was able with silver nitrate to demonstrate clearly cell contours in the epidermis. Keller a little later ('78) studied the histology of Reniera and found that the silver method did give him a well marked system of dark lines forming polygonal meshes. But in many meshes no nuclei were present, while in others they lay in the extreme corner of the mesh, or again, they often lay directly upon the lines. For these and other reasons Keller believed that the meshes did not represent epithelial cells but were to be looked on as artefacts. I agree with Keller in this interpretation. Keller watched the closing of pores in living preparations under the microscope, but does not mention any structure such as the pore membranes of this paper He is perfectly right in discrediting the idea that the pores are closed by the contraction of surrounding muscle-like cells, and is substantially in the right in maintaining that the pores open and close through the movements (contraction) of a superficial layer. As to the nature of this layer Keller at that time followed Haeckel and believed that the outer part of the sponge body (what is usually called epidermis or ectoderm plus mesenchyme or mesoderm) is composed of a soft living sarcode (exoderm of Haeckel) in which certain structures, spicules and some cells, are imbedded. This conception became untenable with the publication of F. E. Schulze's "Untersuchungen" (1875-81).

*Nature of pores.* In the Calcarea specialized pore cells, porocytes, are described, the pore being a perforation of such a cell and therefore intracellular. The porocytes lie at the surface of the simpler olynthus-like forms (Clathrina), but in the more complex Heterocoela they are said to occupy a position in the walls of the flagellated chambers. The apertures at the surface of the Heterocoela, dermal pores, are usually thought of as intercellular gaps, *i. e.*, as apertures each of which is bounded by numerous cells of the epidermis (Minchin '00, pp. 27, 48). In the Monaxonida and other Demospongiae we find as in the Heterocoela, apertures at the surface of the body, dermal pores or ostia, and apertures in the walls of the flagellated chambers, chamber pores or prosopyles. The accounts leave it uncertain as to whether the latter always have the same character (Minchin, loc. cit.) The assumption is usually made that the chamber pores are intercellular gaps. My own observations on this point are limited to the the tetractinellid genus Poecillastra (Wilson, '04, p. 107, pl 15, fig 2). The material seemed to be well preserved and in sections it could easily be seen that the collar cells were wide apart and rested upon a bounding membrane which connected them, and which itself showed no cell boundaries. The chamber pores appeared as perforations in this membrane. If we look on the membrane as formed of thin extensions from the bases of the collar cells, the chamber pores here are equivalent to intercellular gaps. On the other hand there are investigators who think the chamber pores may be intracellular structures. Thus Evans (99, p. 119, figs. 32, 33, 34) is inclined to believe from his observations on Spongilla that true porocytes exist in the walls of the chambers in this sponge.

In our ideas of the dermal pores too a certain vagueness prevails, which can only be cleared up by further investigations. The distinction between the actual aperture and the pore canal should it seems to me, be borne in mind, although where the dermal membrane is excessively thin it may be that such distinction is in practice impossible. Usually the dermal pores are thought of as perforations of the dermal membrane, the two layers of epithelium being continuous round the margin of the pore. Where cell boundaries exist in the epidermis, such a pore, *i. e.*, the actual aperture, would have the nature of an intercellular gap and would not differ in its fundamental structure from an osculum. I conceive the pores in Stylotella and Reniera to be of this nature. Were the epidermis in these sponges divided up into distinct cells, I take it that the pores (comp. figs. 1, 2, 3, 11) would each be surrounded by several cells. The observations of several investigators, however, have inclined them to believe that the dermal pores are intracellular structures, perforations of cells that are comparable to the porocytes of Calcarea In the very young, recently metamorphosed Axinella, Maas ('93, p. 350, pl. 21, fig. 37) finds that the surface views of all his preparations speak for this interpretation. If this idea be true, the porocyte occupies the thickness of the dermal membrane, extending from the outer surface to the subdermal cavity. Delage in describing the recently metamorphosed Spongilla ('92, p. 398, pl. 16), discusses whether the pores be intercellular gaps or intracellular structures, and thinks they are probably the latter. The relation of the porocyte, provided it exist, to the dermal membrane as a whole would here be problematical, since according to Delage, when the pores appear the mesenchyme and the inner epithelial layer of the dermal membrane have not developed. Weltner ('07, p. 276) too is led by his observations on Ephydatia to regard the dermal pores as intracellular. He speaks of them as perforations of the pinacocytes and mentions that the latter can change their shape. It is evident that a more extended, comparative study of the point is needed. It is not impossible that beneath the appearances recorded by the above named authors will be found the structural conditions described here for Stylotella and Reniera. In passing it may be noted that both Delage and Maas figure the epidermis as without cell boundaries.[3] If cell boundaries really exist, it is remarkable that they should not be visible in such thin membranes at a magnification of 750, the magnification at which Delage's figures are drawn.

*Canal epithelium.* The loose epithelioid membrane which I have found lining the canals of Stylotella cannot be an isolated structure. Several facts recorded in the literature indicate that it may possibly be a common type. From among these I may mention the following: Sollas ('88, p. xxxvi) describes the epithelium lining the cortical canals of Pachymatisma as "without definite cell outlines, but the contained protoplasm, however, is very admirably displayed, as a superficially extended film produced into innumerable fine, sometimes branching threads." The thread-like processes of adjacent cells seldom appear to unite, but terminate abruptly." The figure (pl. 31, fig. 22) given by Sollas indicates plainly that the canal lining in Pachymatisma is similar to that in Stylotella. Dendy ('93) finds that the cells of the canal

[3]Delage, loc. cit., pl. 16, fig. 9 b, for Spongilla; pl. 21, fig. 5, for Aplysilla. Maas, loc. cit., pl. 21, fig. 37, for Axinella.

epithelium in certain calcareous sponges, Grantessa, Sycon, Vosmaeropsis are sometimes separated from one another by wide intervals. He regards this appearance as due to contraction, the cells having pulled away from one another. They may still remain connected, he says, in places by strands of protoplasm. Some of Dendy's figures (pl. 14, figs. 60, 62, 64) suggest that in these sponges too the canal lining may be of the type found in Stylotella.

Note—I am fortunately able to refer to a publication by Professor G. H. Parker[4] that has appeared while the foregoing paper has been passing through the press. Parker, in the course of an interesting physiological study of Stylotella heliophila, one of the forms on which my observations were made, touches incidentally on the histology. Some of his conclusions differ from mine.

He thinks that the dermal epithelium is composed of polygonal cells. This conclusion rests on a study of sections which were apparently vertical to the surface and made from osmic material. The dermal layer is so thin that I do not believe it possible to learn much of its structure from such preparations. The same criticism applies to the conclusion that the dermal pores are surrounded by elongated spindle-shaped cells, myocytes, which act as sphincters. Surface preparations, such as those from which my figures were made, show that the pores are not surrounded by cells of this kind.

Parker finds that the canals are lined with flat epithelium. In addition an abundance of myocytes surround the canals (and oscula) arranged like sphincters. "In some places in my preparations they seem to lie directly on the exposed surfaces of the canals and cavities that they bound as though they were merely elongated epithelial cells" (loc. cit., p. 7). It is clear from this quotation that Parker has seen the same elongated epitheloid cells which I have described as lining the efferent canals. My precise observations were limited to these canals, but I may say that I doubt if both an epithelium and an outer sphincter-like layer of myocytes bound any of the canals. Round the osculum the case must be different. Parker here finds a well marked sphincter.

[4] G. H. Parker. The Reactions of Sponges, with a Consideration of the Origin of the Nervous System. Journal Exp. Zool., Vol. 8, 1910.

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## EXPLANATION OF FIGURES

1 Stylotella. Dermal membrane over subdermal cavity—from thick tangenital section. *cc*, cells lining subdermal cavity; *ep.n.*, epidermal nuclei; *m.c.*, mesenchyme cells; *p.c.*, wall of pore canal; *p.m.*, pore membrane; *s.c.w.* wall of subdermal cavity. × (1200 Zeiss 2 mm., oc. 6).[5]

2 Stylotella. Dermal membrane perforated by pore canals—from thick tangential section. Pores closed. References as before. × 1200.

3 Stylotella. Dermal membrane perforated by pore canals—from thick tangential section. Pores partially closed. References as before. × 1200.

4 Stylotella. Dermal membrane showing osmic-silver artefacts. From thick tangential section. × 1200.

5 Stylotella. An oscular lobe was cut transversely. Part of cut surface is shown; canals have been closed in by newly formed membrane. *ch.*, choanosome; *col.*, collenchyma; *c.w.*, wall of canal; *c.m.*, newly formed membrane closing in the canal. × 85.

6 Stylotella. Regenerating epidermis. Exposed surface two hours after cutting. × 1200.

7 Stylotella. Regenerating epidermis. Exposed surface five hours after cutting. × 1200.

8 Stylotella. Regenerating epidermis. From tangential section of new

dermal membrane that has closed in a canal. Five hours after cutting. Body of figure is drawn at a focus below cut surface, and shows mesenchyme cells, *m.c.*; *p.c.*, space in mesenchyme, probably representing pore canal. At a different focus the epidermis, *p.m.*, is drawn where it roofs in the space. In such a position the epidermis presumably forms a (closed) pore membrane. × 1200.

9 Stylotella. Regenerating epidermis. Exposed surface twelve hours after cutting. Pore canals, *p.*, now perforate the dermal membrane; small perforations of the epidermis, *per.*, occur. × 1200.

10 Reniera. Successive stages in the closure of a pore. × 600 (Zeiss D 4).

11 Reniera. Epidermis from an oscular tube. Walls of pore canals, *p.c.*, shown at a lower focus. Pore canals partially or completely closed in by pore membranes, *p.m.* × 1200.

12 Reniera. Successive stages in the closure of a pore. × 600.

13 Reniera. Dermal surface.—from an oscular tube. *p.c.*, pore canal of fig. 12, now closed in and contracted; *a-d.*, cells in the mesenchyme. × 600.

14 Reniera. Successive stages in the closure of a pore. × 600.

15 Reniera. Successive stages in the closure of a pore. × 600.

16 Reniera. Successive stages in the closure of a pore. × 600.

17 Reniera. Three pores showing pseudopodial activity, at margin (*a*, *c*), or at margin of incomplete pore membrane (*b*). × 600.

18 Lissodendoryx. Late stage in the closure of a pore. *p.c.*, wall of pore canal; *p.m.*, pore membrane. × 600.

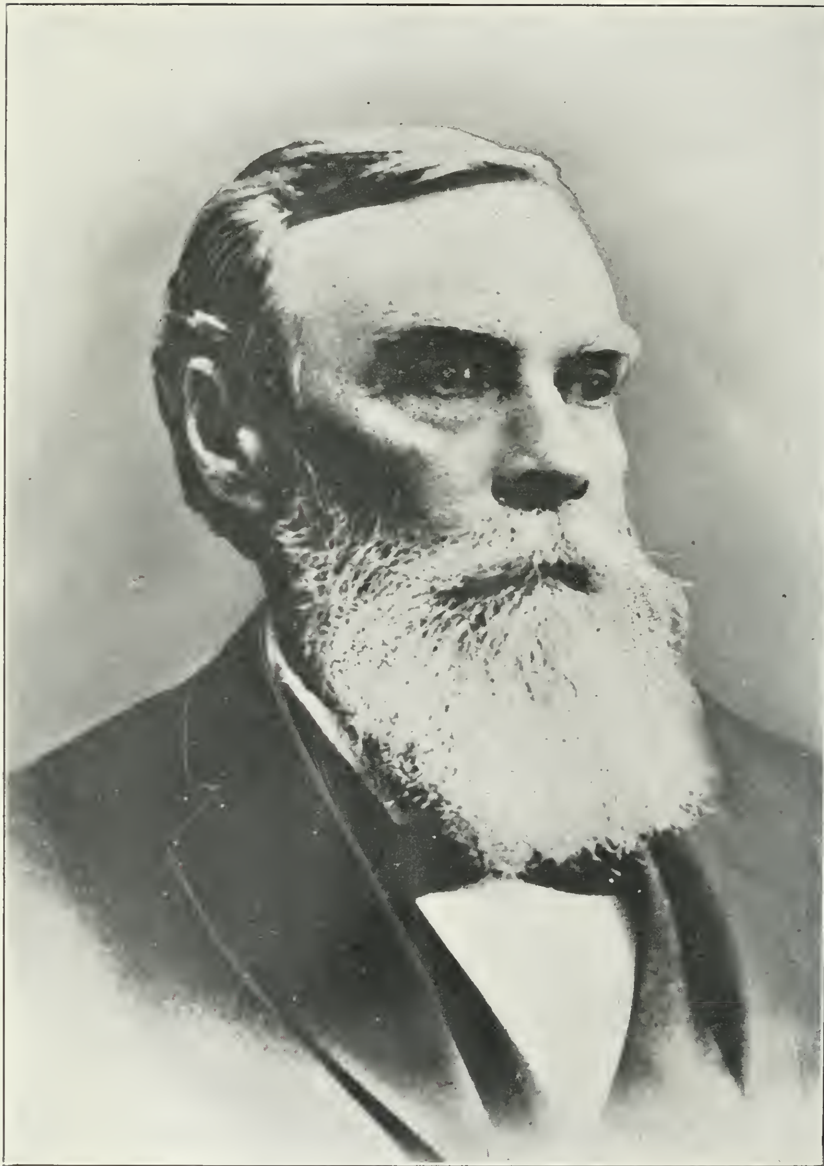
19 Lissodendoryx. Stage in the closure of a pore. × 600.

20 Stylotella. Epithelioid lining of main efferent canal. Alcohol fixation. × 1200.

21 Stylotella. Epithelioid lining of main efferent canal. Sublimate fixation. × 600.

[5] **All figures have been reduced in reproduction by one third.**

**PLATE VI**



JOSEPH HINSON MELLICHAMP
1829-1903.

# DR. JOSEPH HINSON MELLICHAMP.

By W. C. Coker.

Dr. Joseph LeConte in his charming autobiography refers to the fact that while the civilization of the old South produced many men of fine scholarship and great capacity they seemed rarely to have any ambition for the notoriety that comes from publication. Such a man was Langdon Chevis, to whom Dr. LeConte refers, and such also was Joseph Hinson Mellichamp of Bluffton, S. C.

The life that Dr. Mellichamp led was as simple and beautiful as a child's. Though I never saw him I know so well the type to which he belonged—without ever a selfish thought or hope of fame he opened his mind to the inexhaustible inspirations of nature and transmuted them into a faith and love that warmed the hearts of all who knew him. He was one of those who gave the old South its real distinction, a distinction that rested not so much upon the material as upon the spiritual evidences of life.

Several little sketches have appeared that give the salient facts and "superficial vestments" of his days. These are by Dr. S. C. Sargent of the Arnold Arboretum in his "Silva of North America," volume on Cupuliferae, page 144; by Mr. Yates Snowden in the Charleston "News and Courier" of July 20th, 1897; by Mr. W. H. Canby, a well known botanist and banker of Wilmington, Delaware, in Torreya, Vol. 4. No. 1, Jan. 1904; and by Mr. W. P. Gee in the Charleston "News and Courier".

The most important of these is the appreciation by Mr. Canby who knew Dr. Mellichamp personally, and is referred to by him in one of the letters published herewith. I shall give this sketch in full for the light it throws on the character of Dr. Mellichamp. Mr. Canby says:

"Dr. Mellichamp—an excellent botanist of South Carolina—died on James Island in that State on the second of October last.

Joseph Hinson Mellichamp, the son of the Rev. Stiles and Sarah Cromwell Mellichamp, was born in St. Luke's Parish, South Carolina, on the 9th of May 1829. His father was for many years Preceptor of Beaufort College and afterwards was pastor [rector] of St. James Church on James Island. Being a lover of outdoor life and of natural objects, he gave his son a taste for the same and especially for botany, which continued throughout his life. In 1849 he graduated from South Carolina College and in 1852 from the Medical College at Charleston. He then spent some time in Europe, studying at the Hospitals of Dublin and Paris. On his return he established himself as a physician at Bluffton, South Carolina, and he remained there the most of his life—the exceptions being the time when he was a surgeon in the army of the Confederate States and when, during his last years, much of his time was spent with his daughter and only child in New Orleans. It was during this period that, to his great delight, he accomplished a visit to California and its 'big trees.'

Notwithstanding the diligence required to fulfil the responsibilities of a large practice among the planters and their dependents, he found time for much botanical research and collecting. In the interesting floral region around him were many of the rarer species described by Walter, Michaux, and Elliott. Specimens of these were much prized by the botanical fraternity and, through his correspondents, were largely and freely distributed and are now valued samples in many of the best herbaria.

His good judgment in making observations and clear statements of the results brought him the correspondence and esteem of Doctors Gray, Engelmann, and other masters of the science. For Dr. Engelmann he investigated the flowering and fruiting of some species of Yucca, the peculiar oaks of his region, and especially Pinus Elliottii, which he practically discovered and, in the excellent notes he furnished, adequately described. Very acute observations on the insectivorous habits of Sarracenia variolaris were published in the Proceedings of the American Association for the Advancement of Science. In this paper he recorded his discovery of the lure by which insects are tempted to the fatal pitcher of the leaf; of the fact that the secretion therein is more or less an intoxicant; and the curious fact that the larva of a certain insect was able to resist the secretion and to feed upon the decaying mass. Dr. Sargent, in his "Silva of North America," acknowledged his services in the studies of the oaks and other trees. Dr. Gray so esteemed his assistance that he named a Mexican Asclepiad in his honor Mellichampia. Desirous of helping others, he was one of those useful men who, diffident and retiring, and not caring to advance their own fame, are always willing to give to others the benefit of the knowledge they have acquired. It is not too much to say that but for him, considerable of value would have remained unknown of the flora of his district; grateful acknowledgements of this have come from European as well as American botanists.

" Dr. Mellichamp was an ardent lover of nature, with a poetic and artistic spirit, and his letters teem with fine descriptions of the various objects which attracted him in his professional drives about the country. He was wont, as the spring approached, to speak of the exceeding beauty of the young flowers of Pinus Elliottii, as they expanded their cones over the trees, crowning their robes of green with a haze of purple. His letters show the keenest sense of the loveliness and delicious warmth of a spring in the pines with flowers opening everywhere, the fragrance of the woods, of jessamine and of magnolias filling the air made vocal with the songs of mocking-birds.

"But best of all, he was a man to be loved for his qualities of heart and mind. A magnetic and attractive man, his friends and correspondents cannot forget his ready kindness and words of cheer and will cherish his memory. He was beloved by the poor people of his district who, in a touching way, mourned the loss of their "old doctor" as his body was borne to the grave. As might have been supposed he was intensely southern in his feelings and in his love for his native State. He now rests in her bosom, and the well-known lines, slightly altered, may well be applied to him, 'Little he'll reck if they let him sleep on in the grave where a *southern* has laid him.' "

There are some omissions in this as in all other sketches of Dr. Mellichamp's life and in order to fill in some of these I have sought further information from his relative and life-long friend, Mr. W. G. Hinson, a prominent planter of James Island, South Carolina. Letters from Mr. Hinson and a visit to his home have enabled me to add somewhat to the published facts of Dr. Mellichamp's life. In a letter of April 26, 1910, Mr. Hinson says that when graduated from the Medical College of South Carolina Dr. Mellichamp did not go at once to Europe but "was taken into copartnership by Dr. Pope of Bluffton, S. C., who died shortly after, leaving Dr. Mellichamp with a large, lucrative practice, when he took a notion that his medical education was not complete, and that he must spend a year at the hospitals in Europe. His friends tried to dissuade him from such a course, being a young man not well established the field would soon be occupied and he not able to regain what he had lost. The greatest difficulty he had to face was want of means, (His father was an Episcopal clergyman of very limited means, unable to tender him any assistance) fortunately he had an old appreciative friend who loaned him $500 which enabled him to carry out his wish. Two years after his return to Bluffton (which was a beautiful settlement on May River, surrounded by wealthy and cultured planters) his practice was much larger and more remunerative than his partner's had ever been. After the war he returned to his home, which had become almost a deserted country and was so for many years. Many inducements were offered him to go to a city, but his love of the forest and nature was too strong. He had one daughter who married Mr. Woodward (son of an Episcopal Clergyman) who is a dentist of note in New Orleans; they have several children, grown up. When Dr. Mellichamp's health failed he went to his daughter's to live, but returned on a visit to his old home, was spending a few days with me, had retired in the evening apparently well. I was aroused in the next room by a call from him and found him breathing with great difficulty. In fifteen minutes he had quietly passed away."

Dr. Mellichamp was the grandson of St. Lo Mellichamp who

"Died, on the 17th of August, 1827, at his residence, Independent Ridge, St. Paul's Parish, in the 70th year of his age—a soldier of the revolution, and a man of integrity, unblemished throughout life" In his obituary of this soldier, from which the above quotation is also taken, Hon. Henry Bailey, onetime Attorney General of South Carolina, says:

"In politics he was an undeviating Republican of the Jeffersonian stamp, regarding the people as the only legitimate source of power, and their representatives as servants, who are not at liberty to make use of that service for their individual benefit. Thus, when a member of the Legislature he refused a lucrative office, the acceptance of which his friends were pressing upon him, holding it to be a dangerous precedent that a representative should afford the slightest color for a suspicion of having used the influence of his station for his private advancement."

St. Lo Mellichamp married a daughter of Captain Benjamin Stiles who commanded the James Island Company during the Revolutionary War. Another daughter of Capt. Stiles was the grandmother of Mr. W. G. Hinson above mentioned. The Rev. Stiles Mellichamp, son of St. Lo Mellichamp married Sarah Fowler Cromwell, ~~a widow~~ and Dr. J. H Mellichamp was their son. The following notice is copied from the old family bible:

"Joseph Hinson Mellichamp, M. D., son of Rev. Stiles Mellichamp and Sarah Fowler (Cromwell) his wife, born at Gillisonville, Beaufort District, South Carolina, 9th May, 1829; married Sarah E. Pope, daughter of James Pope, Esq., 26 November, 1858, Bluffton, S. C., and died at Stiles Point, James Island, S. C., October 2nd, 1903, at 7 a m., of heart disease.

"Funeral services performed at (P. E.) Grace Church, Charleston, S. C., 3d October, 1903, by the Rev. William Way; and buried at Saint Luke's Church yard, Beaufort county, So. Carolina, twelve miles from Bluffton, S. C., at 12 M., October 4th, 1903.

"After the Confederate war (1860-1865 A. D.) Bishop Howe, of the Diocese of So. Carolina Protestant Episcopal Church, sold the above Saint Luke's Church, located on the Fording Island road between New River and Okeetee River to the Methodists and it is now known as "Bull's Hill Church."

"The church is a quaint wooden structure on the edge of the forest road where Dr. Mellichamp loved to roam in pursuit of his favorite study of the trees and flowers."

Dr. Mellichamp's contribution to a knowledge of southern botany cannot be judged from his own publications. With the exception of occasional letters these seem to be confined to the following:

1st. Insectivorous habits of Sarrecenia variolaris in Proceedings of the American Association for the Advancement of Science.

2nd. Notes from a South Carolina Naturalist I. Garden and Forest, Jan. 2nd, 1889.

3rd. Notes from a South Carolina Naturalist II. Garden and Forest, Jan. 9, 1889.

His principal contributions were in the form of collections, observations and notes that he was constantly sending to the principal botanical scholars of the country. In his study of the Coniferae* Dr. Engelmann of St. Louis, one of the ablest botanists of the times, says: "P. Elliottii was imperfectly known to Elliott and was considered by him a form of P. Taeda. Later botanists ignored it, till Dr. J. H. Mellichamp of Bluffton, S. C. rediscovered it about ten years ago and directed my attention to it. Without his diligent investigations, ample information and copious specimens, this paper could not have been written."

In 1893 Dr. Mellichamp found on a tree of Pinus Elliottii at Bluffton some remarkable bisexual cones (androgynous cones) and these appeared again in other years (see reference to this in one of the following letters). These cones found their way to the hands of Dr. H. Christ who published a technical description of them in Le Bulletin de la Société Royale de Botanique de Belgique. He there refers to Dr. Mellichamp as "our excellent friend, Dr. Mellichamp, of Bluffton, S. C., known for his notable botanical discoveries, and especially for his studies on the pines of his country."

The following observation was written by Dr. Mellichamp in

*"The botanical works of the late George Engelmann", edited by Wm. Trelease and Asa Gray, 1887.

his copy* of Dr. George Engelmann's "Revision of the Genus Pinus."

¶ During this season 1880 (the winter having been very mild) *Pinus Elliottii* flowered from *1st to 10th of February;—P. Australis* and *P. Taeda* almost together about the first week in *March*—the former a little in advance;—*P. Glabra* a little later,—and *P. Mitis* and *P. Serotina* almost together from *1st. to 10th of April*,—the former being a little in advance.

| 1— | 2— 3— | 4— |
|---|---|---|
| *P. Elliottii* | *P. Australis and P. Taeda* | *P. Glabra* |
| 1st-10th Feb. | 1st-10th March. | 10th-20th March. |

5— 6—
*P. Mitis and P. Serotina*
1st-10th April. ¶

J. H. Mellichamp,
Bluffton, S. C.,
20 April, 1880.

In order to arrive at a clearer conception of Dr. Mellichamp's characteristics as a man and naturalist, I have examined a number of his letters that were kindly sent me by Mr. Hinson, who says:

"I have sent you a number of letters with the package sent by this mail, thinking they would give you a clearer understanding of his nature than anything one could say. His being named after my father would naturally cause an interest in him, but it only needed contact with him to be won by his pure and lovely character."

From these letters I have selected the following for publication knowing that they will be more appreciated than any other part of this contribution. The letters, unless otherwise stated, are addressed to Mr. W. G. Hinson, Stiles Point, James Island, S. C. Notes and corrections are by the editor.

*Now in possession of Mr. W. G. Hinson.

Bluffton, S. C.,
24 June, 1892.

My dear William:

Thanks for the specimens of Tilia (Bass-wood,Linden) which you sent me.

I take them both to be *Tilia pubescens*. It differs somewhat from the tree in the mountains and northward—but not much.

Near New River I saw on the *road* a young tree 10-12 feet high which is the only true *poplar* (I don't mean the "Tulip tree"—but the "Cotton wood") which I have seen in the low country, but which is a different species from your "Carolina Poplar" which is found higher up the country and at the north too, I believe.

This I enclose is therefore (so far as I know, and so stated by Elliott) *Populus Angulata** and is a Cotton wood. or *poplar* or *aspen*, and the only low-country poplar we have. The *other* poplar (so called) is no cotton wood—or aspen but the "Tulip tree" or "White Poplar" and its scientific name is as you may know "*Liriodendron Tulipifera*."

Yours truly,
J. H. M.

Bluffton, S. C., 29 March, 1895.

My dear William:

Robert tells me that you want to know where, or how you can get a copy of Dr. Engelmann's "Revision of the Genus Pinus" that contains my old friend "*P. Elliottii*"—the one I rediscovered and sent to the Doctor with my notes etc., from time to time. Yes! a delightful correspondence I had with that genial and kindly man! Well! I don't know where you can get a copy—unless indeed you were a Gould or a Vanderbilt and could bribe some impecunious botanist to whom Dr. Engelmann may have sent the book, for such things are not found in the book stores! I am glad that I can help you and that too without hurting myself. It so happens that through the courtesy of the old Doctor's

*The "Populus Angulata" here referred to (leaves of which are still enclosed) is the true "Carolina poplar" and is now properly known as Populus deltoides Marsh.

son—Dr. George J. Engelmann, and Prof. Trelease of the Shaw's Gardens of St. Louis, and still more through the good Mr. Shaw himself, (who published in one splendid volume all of Engelmann's works), I have a copy which of course includes Dr. Engelmann's *P. Elliottii*. So I have sent it on to you but with *this agreement* which you must promise immediately to carry out, viz: that you will have it bound! It need not be bound expensively, just in boards and tipped on the edges and back with calf or sheep. It won't cost much, but I owe that much to Dr. Engelmann's book. I was afraid I had lost my copy of the pamphlet in a villianous house-cleaning last year, but today I set to work and by good luck found it. And so send on at once to you.

For certain reasons, chiefly to avoid the possibility of its getting into some careless darkey's hands, and its getting mashed up or upset overboard in the Ashley when being carried over to Stile's Point, I have addressed it—registered to Robert† at Chisolm's Mill, and he is a careful man you know, and will put it into your hands safely. What villianous paper these Jews have sold me—the point of my pen actually goes through the paper. Did the pines come all right?

Yours affectionately,
J. H. Mellichamp.

P. S. In 1893-Feb., I found a piece of *P. Cubensis*, *P. Elliottii*, (Engelmann) with most remarkable blooms—many of the aments or catkins having the male or female flowers united, or *bisexual* or *androgynous* which ever you please, and they again appeared in 1894 and 1895. I send you a specimen pressed in the pamphlet. It is not a very good specimen but will do to show.*

Bluffton, S. C., May—'95.

My Dear William:

I received a delightful letter last night from Robert,† in which he told me with great sweetness and simplicity and abounding sympathy, of the great success of the reunion which you inaug-

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*The androgynous specimen still accompanies the letter.

†Robert Mellichamp, his brother.

urated and carried out. I am very glad of it, and I congratulate you with heartiness.

What I chiefly write for now is to ask you, if it is convenient for you to do so, to send to Dr. F. Peyre Porcher, Pinopolis, S. C. (Julian's brother) the copy of Dr. Christ's paper on the Androgynous Catkined pine, which sometime ago I sent you. I sent a small specimen to Dr. Porcher and he seemed interested in it and asked him to send him any paper, etc., of mine, and this is next kin to it. But do not send him my bungling translation, send only the French. Ask him to be sure and return it to you, and don't forget to give him your address. Also enclose him stamp for the return of it, which I enclose. I who am so rarely sick, had a pretty bad attack two days ago, bordering on inflamation of the bowels—due I think to check of perspiration on the bluff after being well heated by a walk. I am now well, but extremely weak.

Affectionately Yours,
J. H. M.

Bluffton, S. C., Feb. 23, 1896.

Rev. Jno. O. Wilson,
Greenville, S. C.

Dear Sir:

I have received the box containing the beautiful specimens of the yellow-berried holly, and I thank you very much for your courtesy. Upon comparing your Greenville specimens with our common holly on the sea coast, I can see no difference save in the size, shape, and color of the berries which are, I think, almost twice the size of ours here, besides being much rounder, and of a bright yellow color. I think also the leaves which you send have stronger and heavier spines than what we find on some trees, but I have seen the spines equally as strong and numerous on different trees with us. Undoubtedly your tree is the same as ours—Ilex Opaca. I send you with this note two or three specimens from a handsome tree growing near my house. You will observe that some of the leaves are entirely free of spines, and that the berries are not as round as yours, and are very much smaller—still both trees belong to Ilex Opaca.

The only holly with yellow berries, which I have seen, was Ilex Myrtifolia, a so-called "variety" of the rare and beautiful Ilex Dahoon, which grows sparsely in swamps along the sea coast. This "variety" I have never seen growing on salt water, but higher up the country, so far up as Orangeburg county, around pineland ponds. It has been seen with yellow berries about Wilmington, N. C , from which place the late Dr. Thomas F. Wood sent me fine specimens. With thanks for your kindness, I am

Very respectfully yours,

J. H. Mellichamp.

This letter is copied from a newspaper clipping of date, March 19th, 1896, in possession of Mr. W. G. Hinson (probably from a Greenville, S. C., paper). At the foot of the clipping Mr. Hinson has written as follows:

"Dr. Mellichamp and myself found both growing in same pond near Summerville in 1898."

Charleston, S. C., August 14, 1897.

My dear William:

When I sent you P. card I forgot to send you also a copy of "Garden and Forest" of Aug. 4th, which I think you will find interesting. I refer you to the articles marked. You can keep them. Suppose you look for H. [Hicoria] pallida in your mountain region, and be sure and save a good specimen of leaf and fruit for me! You have the guide! Yours truly,

J. H. M.

Chisolm's Mill, Charleston, S. C., 2 Sept., [1897?]

My dear William:

Robert hands me your post card so I reply at once. Am glad to know that you looked for Mr. Ashe's *Hicoria pallida*, and perhaps have found it,—will be delighted to see it. Suppose you received the copy of Garden and Forest containing the plate and etc. But you must try and bring also the *nut* in its present condition of growth, and anyone of last year's growth also—if you can!

Mr. Ashe has sent me a specimen of *H. pallida* nicely pressed with nut also. I am getting along and have not bothered to go up to see the Dr. for I believe 3 weeks—and have long since thrown his "truck" to the dogs! R. [Robert Mellichamp] sends regards. J. H. M.

Foot of Trade St., 16 Dec., 1897.

My dear William:

I thank you very much for the fine specimens of Holly which you sent me, and I am curious to know where they came from.

It would not surprise me to find one of them (Ilex Dahoon) on James Island—but the other two (*Ilex Myrtifolia*)† I have never seen on *salt water*, though I have seen it near *Hardeville* both with *yellow* berries and *red*. I refer to the small leaved varieties.

In the *middle* country they are found in, and around pine-land ponds, and they become small trees with very white and smooth bark. They are very beautiful. Let me know where they came from,—if from *James Island*,—at what place,—and is the *yellow* berried form abundant? The other tree with larger leaves and *pink* berries is Ilex Dahoon, and becomes a small tree. It is the *arrow leaved* form of *Ilex Dahoon*. Let me know. I sent these specimens (they were so fine) to Dr. Wm. Trelease of the Missouri Botanical Garden at St. Louis, so if it be convenient for you to get other specimens of *Ilex Myrtifolia* with *yellow* berries and *red* also, I'd be glad—but do not put yourself out or take any special trouble. Yours truly,

J. H. Mellichamp.

P. S. This thing which I enclose (*Illicium parviflorium*)* I found up at *Chicora Park* much of it growing on the avenue just in the rear of the old Turnbull brick house leading to Cooper river.

†Mr. Hinson writes me that he thinks he got this from Summerville, S. C., which is not on salt water.

*The leaves of Illicium are still with this letter.

Have you any of it? It is worthy of cultivation. Leaves when brusied smell delightfully of *sassafras*, or *heart snake root*.*

J. H. M.

I saw one tree up there 35-40 feet high! Elliott says they usually grow 6-10 feet high. J. H. M.

Charleston, S. C.,
Foot of Trade St.,
Friday, 14 Jan., '98.

My dear William:

I have heard that you were back from your duck-hunting trip, but whether you were over-laden with ducks or not—I did not learn! But I hope you had a pleasant time—as pleasant as the one I had in the same Waccamah region with my dear friend Dan Tucker† in the days long past—the days that are no more! Please thank Mr. Ellis for sending me the medical books which I left at your house. I hate to leave, but I *must* go, and expect to start for Bluffton early on Monday morning. I shall remain there a few days, then go on to Savannah, and after a day or so shall boom on to New Orleans. What fate has in store for me *there*—God only knows! I have heard from my friend, Mr. W. W. Ashe, *Chapel Hill*, "*N. C. Geological Survey*" after he received my leaves of the oak which you showed me on the Battery. He says I'm right, that the "Darlington oak"‡ is our "Water Oak"—*Q. laurifolia*, but if you do get specimens of the oak from your friend in D—n, [Darlington, S. C.]§ I wish you'd send them on leaves, acorns and all, and any "notes" you may have about the tree. Goodbye my dear William if I don't see you again.

Yours truly,
J. H. Mellichamp.

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*This is Asarum arifolium Michx., often called "Heart Leaf."

†A wealthy rice planter of Georgetown, S. C., and a class mate of Dr. Mellichamp at the South Carolina College.

‡More widely known as "Laurel Oak." The name "Darlington Oak" comes from its use as a street tree in Darlington, S. C.

§He refers here to Mr. W. D. Woods, of Darlington, S. C., who has been interested for years in the trees of his section. He is still living.

New Orleans, La.,
Cor. Fern and Elm Sts.,
18 Feb., '98.

My dear William:

I am sorry that I did not reply just as soon as I received your letter with Mr. Ashe's papers, but the fact is, I was not very well and so put it off for a more convenient season!

And if a thing cannot be well, and properly, and faithfully done, it seems to me it had better not be done at all, and so stands the case about the queries as to the young live oak, and the young magnolias! If I could only have received these queries when I was last in Bluffton, I could have answered them *accurately* but now I cannot do so, and I do not wish to trust to my memory of some years back when I not only planted the live oak acorns, but examined the young roots after a year or two and even reported the results to my dear friend Engelmann of St. Louis *who had been put on the track by Wm. St. J. Mazyck* who spent a pleasant morning with me at the mill, when I was last in Charleston. The results are published in Dr. Engelmann's works I think. Should I ever get back to the low country in S. C., I shall take the greatest pleasure in examining both the live oak and the magnolia,—but now I'd prefer not to trust too much to (perhaps) a treacherous memory! I am very sorry! I enclose Mr. Ashe's papers as perhaps you will need them. I thank you very much for getting and sending the specimens of the so called "Darlington oak" to Mr. Ashe.

When I was last in Bluffton I sent him quite a lot of specimens of a curious oak which I had found on the roadside some years before which *seemed* a *hybrid* between the "Water oak," our low country "*Quercus* (laurifolia)", and the "*Q. Cinera*", and it had two sets of acorns, the *one* "*annual*," the *other* "*biennial*," that is, the one set *maturing* in *one* year, like the "Live oak,"—the other in two seasons like the "Water oak." It was very curious, and evidently all is not known yet as to the queer ways of our oaks!

I like this old place very much, and everybody here is at this present time talking and talking and talking about the "Mardi

Gras'' or whatever they call it. I am sorry that such things do not interest me now,—but thank God! the woods and fields and trees and plants do interest me still.

Two of my grandchildren have been sick with grippal pneumonia and pleurisy, and Herbert from having been overdone by a long bicycle ride away off to Lake Pontre-Chartrain (or however these French people spell it) last Sunday.

Both thank Heaven are now well. Mary sends you much love, —she can't forget those very happy days you and yours gave her long ago at Stile's Landing! Well, I must have tired you out my dear William.

Yours truly.

J. H. M.

I had one "bout" the other day, waiting in the streets with Iva for the street cars.—losing somewhat of speech and with a kind of a dull and stupid feeling in the head, and the *effects* I felt certainly for 2 days! Now I feel quite well. When you see Elias Rivers give him my love and do William look after my dear Robert* for me and let me know about him.

New Orleans, La.,

Cor. Fern and Elm Sts.

My dear William:

I received your letter enclosing one of Mr. Ashe's last night and reply at once about his pine. What he alludes to as the "Slash Pine" is nothing but the same pine as the seedlings which I send you from Bluffton—otherwise called the "Cuban Pine" (P. Cubensis), or P. Eliottii, [P. Elliottii], or P. Heterophylla, which Elliott first called it as a variety of the loblolly pine (P. Taeda) but he never made a greater mistake in his life, as it is no "variety" but a true and genuine species. It is the only pine on our coast which has purple "catkins" or flowers except the long leaved yellow pine (P. Australis) and it bears its leaves as I have shown you by twos and threes. The scales or flakes of bark are also thinner and longer usually than those of the long leaved pine and of a kind of violet or bluish or pinkish color. You will hard-

*Robert Mellichamp, brother to Dr. Mellichamp.

ly find it in the Island. I only saw one tree there when I was a boy in College, and it grew on the bluff or edge of it, not far from the Nartello tower. It was the first tree of the kind I ever saw, and I was struck by the appearance of the cones—their beautiful shape and color. I collected a good many of them for my dear Sister, as she was (at the suggestion of Wm. M. Lawton) making basket work of pine scales for the great exposition in Lòndon at that time. She received her testimonials through Mr. Lawton. I never saw another of that species of pine on James Island although I always kept my eyes open, but I did see the pollen from similar trees wafted in immense clouds (*earlier than that of any other pine*) when I was fishing or exploring in Great Creek or about Black Island.* I once killed on Black Island an old eagle and two grown young ones, and the nest was also on one of these trees, (P. Elliottii). Pardon my dear William the garrulity of age and my allusion to these delightful days, the happiest of my life. I shall never see the like again, and it is a delight to allude to or think of them! I feel pretty sure that I saw the same tree growing on "Goat Island" in my trip with your father to Bird Key, but I guess you won't find it now on James Island. I wrote to Mr. DuBois in Bluffton telling him that I'd be glad for him to send specimens of the tree to Mr. Ashe and I'd send stamps, but I do not know whether he had time or inclination. I sent Mr. A. the same androgynous specimens which were just commencing to bloom when I left Bluffton, and this is what he alludes to in his letter to you. Had I known that Mr. Ashe wanted specimens of P. Elliottii when I was last in Bluffton, I would have taken pleasure in getting them, or having them gotten by somebody at the right time, if Mr. DuBois couldn't get them—but he may get them as I know him to be kind and obliging.

We are in the midst of all the row of Mardi Gras about which

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*These observations on the occurrence of Pinus Elliottii at and near Charleston (James Island lies right across the Bay from the Battery) are very interesting. Mr. R. M. Harper who has carefully studied the distribution of this pine says: "It perhaps does not grow within thirty miles of Charleston." (Bulletin of the Torrey Botanical Club, Vol. 34, page 375, 1907).

the French people go mad, but I did not go out last night with John W. and his boys, as I find it impossible to feel any interest (Alas! Alas!) in such things. But I'll try tonight unless I get too "stubbornt" as the Crackers say. If Mary was down stairs she would, I know, send her love. John W. is in partnership with a fine man and I may say he is doing well. I wrote you a few days ago, returning Mr. Ashe's letter and the Darlington man's.

Yours very truly,
J. H. Mellichamp.

New Orleans, La.,
Cor. Fern and Elm Sts.,
April 18th, 1898.

My dear William:

I fear you are thinking me a troublesome customer, but I can't help it, as I greatly wish to oblige Prof. C. S. Sargent. A short while ago Mr. Sargent wrote me, begging me to send him from the sea-coast a good specimen of our common *Red Cedar* as there were questions about it and the *Bermuda Cedar* which he was anxious to settle. I immediately wrote my friend Mr. DuBois of Bluffton, enclosing to him Mr. Sargent's letter, and asking him to send him a specimen with *the berries* (if possible) but I have since heard from Mr. DuBois as to other matters, and as he did not say a word as to my request (I sent stamps), I fear that my letter miscarried in the mail. Now I've just heard again from Professor Sargent and he thanks me for my attempt, but up to that time the cedar has not arrived, so I conclude that Mr. DuBois did not receive my letter. But Mr. Sargent wants specimens from *different places*, so I write you, begging you to send him a specimen or two *with the berries*, if possible, and on the parcel putting on your name thus, "*Botanical specimens*," from Wm. G. Hinson, James Island, S. C., then the address thus—Prof. C. S. Sargent, *Arnold Arboretum*, *Jamaica Plain*, *Mass*.

That will keep the parcel from being torn to pieces by mail people probably. Yours affectionately,

J. H. Mellichamp.

P. S. The *Trillium* I wanted was sent me by our old friend from St. John's, Mr. Porcher, so you need not think of it again. I sent Robert Mellichamp a specimen for you, so that you may *know* it.

May sends her love to you. I am feeling very well, but I am too dull and stupid—indeed *that* is now I fear a chronic contagion with me!

"Solemn before us, veiled the dark portal."
"Grave of all mortal"! J. H. M.

New Orleans, La.,
Fern and Elm Sts.,
26 May, '98.

My dear William:

I replied to your kind letter yesterday, but in reading it over again this morning I find there were one or two queries which I neglected to reply to. You ask if I had seen Dr. Chas. Mohr's book on Forestry. Yes, I have it, sent me by Dr. M. a few years ago. This was the edition of '96, but yours is I suppose a later and last edition.

The old Doctor paid me a visit in Bluffton some years ago, and stayed a few days with us. We were all very much pleased with him. He is an accomplished man. He is a druggist in Mobile and has sons and daughters too I think. His home is but a short distance from this city, as you know, and he spent a day with us the other day, dining with us, etc. I fear his health is not as good as it was. He looks much older, and he is now an old man. I may one of these days take a trip to Mobile, and perhaps go about with him a little in the woods. He is a most pleasing man, and has been all over the world.

That magnolia which you met with in Mr. Middleton's garden may not really be the same as the "Umbrella tree" in the C'h woods. It *may* be the "Magnolia Macrophylla", which is "found in Tennessee and 10-12 miles to the S. East of Lincoln court house, North Carolina." Elliott. The leaves are very large "They have been found thirty-five inches long, and 9-12 inches wide," etc. I wish I could see it in its native haunts. The other day I was strolling (over a month ago), and I stumbled over a water plant in "Audubon Park" which I had been looking for all my life in our low country, but never could find. It was the "Tawny Iris." Irish Cuprea Pursh. I found a great many growing in a ditch in the park. I became as you may imagine very much *enthused*. It was like meeting a very old friend. Elliott says it "grows in the marshes of the Altamahah" and cites LeConte. I enclose a small specimen, and when the seeds are mature, I shall manage to get some and let you try them in some bog near your house, if you have *such a thing as a bog* now, which I am afraid you haven't!

And so the poor little Seabrook boy has gone or is going the way of all flesh, except wise old fellows like W. G. H., but then its doubtful, for you manage to take the cares of other people upon you in addition to your own, so nothing is gained after all! I shall in a few days send you a few acorns of the Texan Oak (Q. Texana) which the people grow on their sidewalks, and you can try and grow it at your place. Well, I believe that is all I have to say just now.

Yours affectionately,
J. H. M. (Mellichamp.)

New Orleans, La.,
Fern and Elm Sts.
27 June, 1898.

My Dear William:

I received your letter some days ago, and thank you for the enclosed specimen which you sent me. I examined that flower some fifteen years or more ago and if I remember a-right could not find it in any Southern Bot. work which I had, either Elliott's or Dr. Chapman's and of these I have at present only Elliott's. I think it is no Southern plant, and don't know why it should have been planted by the *Perronneau** people as I suppose it was. I think I must have sent it to Dr. Gray, of Cambridge but I have forgotten the name, but think it commenced with a C.

*An old Carolina family of James Island. Their place is now owned by Mr. W. G. Hinson.

Today I sent it to Dr. Mohr* of Mobile, who lives near here, and indeed came to see me the other day, spending the day with us, and dining with us. Nice German gentlemen and accomplished wants me to go and see him. I'll write you again when he gives me the name.

Something I want you to do for me again. I want a specimen of the *Gonolobus Vine* that bears yellow flowers and grows on the road near the gate to the *right*, where I got the pink flowered Eupatorum which you got for me on the *left* of the road. The vine exudes milk when you pluck the flowers or leaves.

[Sketch] The petals are somewhat *veined* and the leaves are generally large and heart-shaped [sketch] and rather hairy. The specimen ought to have one or two clusters of *pale-yellow* (*sometimes* brownish purple) flowers, 6-8 inches long and pressed, and keep till dry, or flat. If troublesome don't bother, and you can send one little bit of the other, the *pink* Eupatorum, but if either of these be gotten, you must carry with you a book, and on the road press at once before wilting occurs. The Gonolobus bears a round capsule which is *prickly*. [sketch] The other kind has *angled* capsules and very smooth and grows on the McLeod road and has *purple* flowers—dark purple [sketch] petals not *veined* and sharp pointed. Yours very truly,

J. H. M. [Mellichamp.]

New Orleans, La.,
Cor. Fern and Elm Sts.,
July 13, 1898.

My dear William:

I received your package of beautiful plants a mail or two after your letter came, and I thank you very much. The plant *Gonolobus hirsutus* was just what I wanted, as I wished to compare it with a vine which I found growing here occasionally in the gardens, and even along the sidewalks.

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*Dr. Chas. Mohr, a druggist and a botanist of distinction. His large work on "The Plant Life of Alabama" is well known.

If I can find the right book which I pressed it in, I shall enclose it in this letter. I was quite curious about it, especially as I had left Dr. Chapman's book at home and therefore could not satisfy myself about the name. However I sent a fragrant of it to my good friend, old Dr. *Chas. Mohr* of Mobile (he came to see us the other day and spent the day with us) and he gave me the name stating that some weeks ago he had collected it himself in Central Ala.

It is not found about our Sea-island country of South Carolina, so it was quite a stranger to me. It has the yellow or straw colored flowers of your *hirsutus* but not the shape of the petals, and its leaves are exactly like the vine that grows along the McLeod hedge, and the flowers are of the same *shape* only they are not *dark purple* as *they* are but (as I said) yellow or straw color. Dr. Mohr said it was *gonolobus flavidulus*. Here is an outline of the petal of your hirsutus [sketch], here is one of *flavidulus* [sketch] the one more rounded and blunt, the other more narrow, and sharp pointed. The difference *you* may say, "twixt tweedledum and tweedledee." But both your plant and mine of New Orleans have their flowers straw colored.

Much ado I'm afraid you'll say about nothing, and yet these distinctions are absolutely necessary! As I told you, May and I did not get to see your friends down town, for my own sickness or indisposition with the downpour of rain prevented and we could not go and now we see from the paper that they (at least the ladies) had *gone* to Saluda, but we shall go again if there are any left. We liked them all *very much*. It would give me an immense amount of pleasure to come to your house and stay while with you, but I don't know if I can compass it. But I must think it over.

I heard yesterday—long letter—from Mr. Arthur Huger. He is at Waynesville, N. C., at Pink E. Hyatt's. That vine of yours G. hirsutus (hairy) that has the straw color or yellow flower—has also sometimes flowers *dark colored* a *kind of chocolate color*, but different from the G. M. (Gonolobus Macrophyllus Michx.) at McLeod's fence. The fruit of the former as you must know, both the chocolate and yellow colored kind is *round* and *prickly* and that of the other *smooth* and *angled*—not round.*

Yours affectionately,

J. H. M. [Mellichamp]

Fern and Elm Sts.,
New Orleans, La.,
26th Aug., 1898.

My dear William:

I received your card yesterday, and thank you more than ever for your affectionate invitation. You are very good to me, and I feel sure I would have a grand time with you and Mr. Brewster in the woods and everywhere—but I cannot come! Some other time perhaps if it suits you in the days to come—I shall give myself that pleasure—but not now!

How curiously a man talks of the future—"Days to come," as if I had the years of Methusaleh ahead of me, and had not already almost hoed out my row of the three score years and ten! Well! it's no wonder we cling to the years we have known and hope to have here,—for after all it is all we know, and we know nothing of the other world—the world to come! I hope it is a good place and hope I shall get there when I go—but it is doubtful. I much prefer this present world with its uncertainties and Deviltries—it being the only one I *know*!

But all of such talk is nonsense—let me talk of things more pleasant. About two weeks ago John Woodward had a little holiday of two weeks, and we agreed on taking a small "outing"

*In addition to the two sketches of petals inserted in the positions indicated above there are two marginal sketches of the fruit of Gonolobus hirsutus and G. Macrophyllus respectively.

Gonolobus flavidulus Chapm. is now generally considered only a variety of G. hirsutus Michx. The earlier generic name of Vincetoxicum has been adopted instead of Gonolobus for these species and they are now known as Vincetoxicum hirsutum flavidulum (Chapm.) Vail. and Vincetoxicum gonocarpus Walt. Inclosed is a specimen of "Gonolobus flavidulus" (leaf and flowers).

with grandson *Joe** at Covington, which is some 60 miles from New Orleans. And so we went,—and a delightful time we had—or rather I had, for it rained more or less the whole time we were away. The hotel was full where we expected to be entertained, so we went out into Pinelands, some three miles off, with a German—or rather the son of a German, by name of Zeit Vogel, who took care of us and did the best he could (which was not much) for our comfort. His house was on the banks of a little stream with an Indian name—*Bougfalayah* he called it, but I don't know what that means, but it sounded Indianlike and all right, so John and Joe thought it would at least give them a few cat-fish, or a perch (pache, the Savannah River niggers call it) or trout. So they rigged up their lines and tried the most inviting looking spots on the river—but not a bite did they have. John evidently was in hopes of doing *such* fishing as that he used to do on the "Rocks" in May River—or about Dawfuskie, or Calebogie—but it was no use—they did not have a bite, so they were just in the humour to accept my invitation to other fields and "Pastures New," and that was into the beautiful Beech and Magnolia woods on the banks of the Bougfalayah, where it seemed likely I would see some fine things. And so we did. I soon got John and Joe into an enthusiastic humour, and in a little while I had them showing me, or bringing me the finest or most wonderful specimens of shrubs and plants. It is curious, isn't it?—how you can get people by a sort of contagious enthusiasm into exactly the right mood which you would wish them to be in to help you!

The first thing I struck was *Illicium parviflorum* (or Floridanum) of old Michaux who first found it I think on the St. John's River in Florida. I have searched *our* woods in Carolina in vain for it —never could find it *in the woods wild*, and saw only one shrub on the Okeetee which had been dug from poor Langdon Chevis' garden on Savannah River when he was engineering at Batten Wagner and losing his life too! Poor fellow! I liked him so much, he seemed a very accomplished man when I met him at the Hilton Head forts. I next met this shrub last year at "*Chicora*" (Turnbull's old place) where I saw one tree about 40 feet high,

*Joe Woodward, a grandson of Dr. Mellichamp.

but no tree there had either flower or fruit. But those on the Bougfalayah river were full of fruit, and Joe with a great air of triumph brought me a single flower—growing out of all time and season from a shrub. I guess this shrub is in the gardens of Sav. and Charleston, etc., but I never saw it *wild* and growing in the woods but near Covington. I saw other things, but I weary you, so stop, and I thank you very much, my dear William.

Yours affectionately,

J. H. M.

P. S. If I can squeeze into this letter a specimen of the *Illicium Floridanum** with leaves and *fruit* I shall do so, and I'd like you to keep on the lookout for it, but I don't expect you to find it. If Mr. Dill is up there will you please give my regards to him.

New Orleans, La.,
2 April, 1900.

My dear Robert:†

I think I sent you a postal a day or two ago, telling you that both Prof. Sargent and Mr. Canby had suddenly burst in on us—asking me to pilot them through the Covington swamps and show them the fine *Illicium* which I had found there a year or two ago.

I wish I could have had them to dinner, but my poor daughter was badly fixed for it, being be-devilled by servants as she was who might be termed of the Devil incarnate order. So after my making an agreement to meet them next morning at the Depot (Sunday) they bade me goodbye. I found Mr. Canby a charming gentleman and brimful of humour—he and the Prof. poking a great deal of fun at each other, to my great amusement. For the last fifteen or twenty years they have been travelling more or less together over the whole of the U. S., both South and North,—but Mr. Canby had never been in New Orleans before,

*Specimen enclosed of Illicium floridanum Ellis. Illicium parviflorum Michx. is another species that is supposed to be confined to Florida and Georgia.

†Robert Mellichamp, his brother.

so everything was fresh and new to him The next day they both went to Miss. City (wherever that may be) but they did not find what they were after—(a haw, I think, Crateegus) and upon the whole they didn't seem to think Miss. City any very grand place I suppose for lack of the Haw!

So at four o'clock Sunday morning I got up, fearing that I might oversleep myself, and I guess it was perhaps a half or two hours before Herbert* and I were off into the street cars bound down town—but the two travellers were not to be seen. A great many Franco-English Fishermen were crowding the platform with all sorts of rods and reels and fanciful baskets—the former of which I thought would have delighted the eye of Father.—(You remember what a taste he had in going up to "Stones" on a fishing expedition.) But we saw no Mr. Sargent and no Mr. Canby with their accoutrements to entrap their floral treasures and we had almost given them up, when almost at the last moment here they were all chip and cherry and not thinking they were too late—as *is the way with* old travellers!

The cars were packed with all manner of people, all more or less bent on fishing seemingly in the Pont Chartrain, Lake County, and so packed were the cars that we could not get a seat together,—but the whole scene was so new and strange and pleasant with a kind of Frenchy air that I at least enjoyed it immensely.

Pont Chartrain, on the edge of which we travelled for a long distance through marshes and bogs, is I believe some 16 or 20 miles wide and at last we seemed to cross it completely when eventually we got over into a desolate pine-barren country and then we made good speed. Prof. Sargent seemed very much interested when I told him that I expected to meet with on our journey a good many trees of the *Smooth Spruce* (Pinus Glabra) which I promised to point out to him. He seemed very much surprised, having expected to find them in a flat, clay like country, but I told him we would come to cave-like drippings in the woods—unless I was greatly mistaken where we see them. But on and on we went

*Herbert Woodward, a grandson of Dr. Mellichamp.

and no *Pinus Glabra* did we see and I commenced to feel a little foolish, thinking that perhaps I had seen the trees in some other region, maybe in *Alabama* or even in Carolina, but all of a suddent—(as Crackers say) here was a low dip and here were the Pines first discovered by the St. John's Berkley Englishman, Walter, who settled and married in that Parish and who was buried on "The banks of the Santee." Dr. Peyre Porcher was his descendant and heired his botanical tastes, and the Charlton family in Sav. Ga., are also his descendants. Walter married a Miss Peyre and I suppose that it was from that family that Rush Gaillard's brother, *Peyre Gaillard*, took his name. Kinsfolk I know they were. Mr. Sargent, I could see, was very much pleased to find another station so far west and for *P. Glabra*, as he maps out the bounds and measures of the different species, and evidently he was quite unprepared for this new place.

I told him I'd show him a good many along the Bugfallgah—or whatever the name may be. That is the river which runs through the swamp 3 miles from Covington, and I did show them to him *there* and further on the R. R. So I saved my bacon, as I may say, for really I commenced to tremble in my shoes (as Squire used to say) and feared that my Pinus Glabra was not "Come-atibus in Swamps"—but it was!

At last we reached Covington and I looked for the Dutchman (Mr. Berg or Burg) to whom I had sent a postal to meet us with his team, but no Mr. Berg was to be seen, so at last Mr. Canby hired a buggy with a scary, balking horse—he and I taking the back seat and Prof. Sargent and the driver in front and away we went for the swamp three miles off.

A lovely and a most brilliant day and cold enough to make even my heavy old overcoat comfortable and I commenced to feel even still more happy than when I was travelling on Pont Chartrain and almost as happy as on that never to be forgotten day which I spent in the Church Woods with our dear Father in November—a year or two before our war of ruin and disaster. Have I ever forgotten the Beech trees and the sunlight in their green and yellowing leaves or the towering pines of *P. Glabra* or the long, deciduous, banana like leaves of the beautiful Magnolia—the first which I had ever seen—or Father's enjoyment of the scene—his enthusiasm, his lovableness? No, let my right hand forget its cunning before I forget that day of all days—or I forget that sweet day which I spent with you—Xmas day, wasn't it?—when we went down May River together to Old Island and we saw many of the wonders of the world there and came back home brimful. No, I won't forget *that* day either—never. Well, such a day was yesterday with Prof. Sargent and Mr. Canby! They were as happy as boys, and I not so far behind, and I won't forget that day, either. They were very courteous and good to me, and a grand time did we have on the roadside, for at times we jumped out of the buggy and we admired the splendid trees on the edge of the Caves,—the early flowering shrubs, and all of a sudden here was *Illicium Floridanum* in full and bounteous bloom from top to bottom. We never expected such a sight—the crimson flowers were very beautiful to us and never had any of us seen such a profusion of flowers. Mr. Sargent was inclined to think that this shrub differed a great deal from the *Floridanum* and I would not be surprised if he did not make even a *new species* of it. Such profusion I never before saw, and the flowers in full and perfect bloom from top to bottom, and almost everywhere—and strange to say, the shrubs growing in whitish, sandy land, but still, near the waters of the Caves. Never saw anything like it in my life before, or such enthusiasm on the part of those *Veterans*, I may say.

Still, we were, I may say, just on the edge of the Swamp and the perfect glories within had hardly been revealed to us. I had promised to show Mr. Sargent a shrub like tree full 30 feet high—measured at least it had been by John Woodward's careful eye, but that tree I could not find—greatly to my *discomfiture!*

I had given to Mr. Sargent John's very good and accurate plot of the swamp and his idea of the position of these one or two largest trees, but although I found several or many which were 15 feet or perhaps 20 feet high, the 30 foot one I could not locate. So we had to leave the swamp without finding it, *yet I know it is there*, and I think John could find it if he too should come once more into that beautiful region. Mr. Canby was always talking about *lunch*, but I thought we could go on, so Mr. Sargent agreed with me to go on and on, for I was in that state of enthusement (such a word?) that like Tennyson's Brook, I felt as if I could go on "forever," and neither of my friends were at all far behind me! but I must stop my too swiftly *current* and *hilarious* pen, is it?—for the time flies as I'm writing an account of these delightful hours spent yesterday and I must keep my engagement to meet Mr. Sargent in an hour or so at the St. Charles Hotel to take lunch with these "grands hommes," as I must call them, and then I'm to carry them to the City Park to show them some grand live oaks and a hickory tree (C. Aquatica) of which I sent Prof. Sargent some months ago, the finest he said as to *fruit* he had ever seen.

So time is flying and go I must and finish my letter another time, so for the present goodbye, and I'll send you one or two of the specimens of *Illicium* when I finish. J. H. M.

Late in the afternoon and I've just returned from City Park, where I spent a pleasant time, but not approaching the glorious times of yesterday—such delights (from their novelty also) don't come to us every day—about 3 or 4 times in a *whole life time!*

Better so,—we will value them the more when they do come! We are not apt to get a surfeit, that's certain.

I showed Mr. Sargent the two grand oaks—*Louisiana* oak and the *McDonough* oak, but told him there was one at Caper's Landing, S. C., bigger still—but in my day even it had been mutilated by hurricane and cyclonic storms. They gave me a grand lunch of sheepshead and other fine things at Mr. Victor's—a sort of French Restaurant—where we were admirably served, also nice Claret which I very much enjoyed, winding up with Cafè noir.

I could tell you more about the original trip and all the other fine things we saw, and the fine things we did, but I'm a little bit tired and I guess I have said enough for one time—only I must allude to our balking horse d—l that I almost feared he was going to kill us, but we got off slick enough.

Love to Stiley. I dare say he got my love letters.

Affectionately,

J. H. M.

Plate I.

François André Michaux

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# THE GARDEN OF ANDRÉ MICHAUX

By W. C. Coker.

Among the earlier botanical explorers of America none prosecuted his studies with more energy and enthusiasm, or met with more courage and fortitude the hardships and dangers of extensive travels in the wilderness than that restless and indomitable spirit, André Michaux, of France. The studies and travels of this distinguished man are accessible to students through the Journal of his travels, written in French, and through his botanical works, but the extensive Southern garden that was established by him, with the assistance of his son, François André, who was then but a lad, cannot be definitely located by referring to their works. So far as I know the only account of the location, history and present condition of the garden is contained in a letter by Judge Henry A. M. Smith, of Charleston, to the Charleston *News and Courier* of August 23, 1905. This is, of course, not accessible to many, and as a result there is very little known in regard to the garden by botanists in general. To bring the facts within the reach of the student is my excuse for this communication.

I shall first give a copy of Mr. Smith's letter. He says:

" In the *Sunday News* of August 20 it was stated in your Columbia correspondence that a letter of inquiry had been received concerning the Bot. garden of André Michaux, near Charleston.

" The site of the garden is near the Ten Mile Station, on the Southern Railway. It lies on the north side of the track, about a half mile west of the station and some 400 or 500 yards from the railway line, in full view of passing trains.

"André Michaux was sent out by the French Government — the Royal Government — to investigate and introduce into

 Printed June 26, 1911

France such trees and plants of North America as would be acquisitions of value. In 1786 he purchased this tract of some 111 acres and there established his so-called garden.

" It was rather an entrepot or place where he planted the seeds of promising trees, shrubs and plants, so as to have young seedlings and fresh seeds in the best condition from time to time to ship to France by the comparatively slow sailing ships of the period. The garden was sold by order of the French Republic in 1802. The deed of sale on behalf of the French Republic was executed by André Michaux, the younger, the son of the first, and himself an eminent botanist.

" The journal of the elder Michaux shows that he spent a very considerable part of his stay in this country at this garden, engaged in the cultivation and selection of the trees and plants collected by him over the Eastern United States. The garden was apparently kept up for some time after the sale, and was for a period owned by the Agricultural Society.

" Nothing now remains of the garden proper save the lines of a few old drainage ditches and ponds long silted up. The position of the old dwelling is marked by some broken bricks and a grove of trees, oaks and magnolias, said to have been planted by Michaux. When the writer first visited the spot, some fifteen years ago, there was a fine *Salisburia* or ginkgo tree, but this has since disappeared."

As the "Journal"* of Michaux begins with his arrival in Charleston in 1787, thus indicating an inconsistency of dates, I wrote Judge Smith as follows:

" I notice in your letter to the *News and Courier* of August 23rd, 1905, the statement that Michaux purchased the Garden tract in 1786. In his introduction to the Journal of Michaux, Dr. Sargent says that Michaux first visited Charleston in 1787, and I notice that his Journal begins on his arrival in Charleston April 19th, 1787. Had he been to Charleston before this, or is 1786 in your article a typographical error?

" I cannot find any mention of the Garden in the Journal

*Journal of André Michaux 1787-1796 with Introduction and Notes by C. S. Sargeant. Proceedings of the American Philosophical Society Vol. 26, No. 126, 1889.

before the page 22: does his reference here to securing land for the king mean that this is a date of purchase (July 12th, 13, 14, 15, 1787)? The deed will be the best evidence."

To this Judge Smith gave the following reply:

"From the record it appears that the tract of 111 acres near Charleston, afterwards known as the French Garden, was conveyed by Lewis Besselieu to André Michaux by deed dated 3 November 1786, recorded in Book Y, No. 5, p. 131. The same tract was conveyed by Fr. André Michaux (Michaux fils) to John J. Himely by deed dated 8 March 1802, recorded Bk. G, No. 7, p. 102. There is also on record (Bk. F, No. 7, p. 333) an agreement between Fr. André Michaux and John J. Himely dated 27 April 1802 setting out that this property had been originally acquired for the French Government and that the proper department of that government had authorized Fr. André Michaux to make the sale but reserving to Michaux the use of the property until 1 March 1803."

It will be seen from this that there is still an unexplained inconsistency between the Journal and the deed. Did Michaux visit Charleston before 1787? Or did he buy the land through other parties without having seen it? He came to America for the first time in 1785, arriving in New York, and he is supposed to have remained in the North until he sailed for Charleston in 1787. I know at present of no way of settling this point, but other sources of information may yet appear.*

The old garden property has changed hands a number of times recently, and is now owned by Mr. St. Julian Kestler, of Ten Mile Station.

Michaux remained in America for more than ten years, and if he can be said to have had a home in America it was at this garden, where he had a residence, and in his Journal he makes frequent mention of the garden and of his work there. It was from this point as a base that he made extensive travels into the Alleghany Mountains, and into Kentucky, Georgia, Florida, the Bahamas and other islands. On some of these trips he was accompanied by his son, François André, who, on

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*In a recent letter Judge Smith suggests that the deed may have been antedated.

his first arrival in America in 1785, was a boy of but fifteen years. The young François was also of great assistance to his father in collecting and planting seeds, resetting and propagating plants, and other such exacting and laborious work of the garden. This training was of great assistance to the younger Michaux in his future career as botanical explorer and author. There is no known portrait of the elder Michaux, but there is a daguerreotype of François André, made in 1851, which we reproduce as the frontispiece of this issue (Plate I).

In 1796 André Michaux returned to France and after further travels died in Madagascar in November, 1802. The younger Michaux, who had left America before his father, was sent back in 1801 by the Minister of the Interior, of France, with instructions to ship all available nursery stock from the garden to France and then sell the place. Almost immediately on his arrival in Charleston, in October, Michaux was attacked by yellow fever, which disabled him for over a month. In his "Travels"* he says:

"As soon as I recovered from my illness I left Charleston, and went to reside in a small plantation about ten miles from the town, where my father had formed a botanic garden. It was there he collected and cultivated, with the greatest care, the plants that he found in the long and painful travels that his ardent love for science had urged him to make, almost every year, in the different quarters of America. Ever animated with a desire of serving the country he was in, he conceived that the climate of South Carolina must be favorable to the culture of several useful vegetables of the old continent, and made a memorial of them, which he read to the Agricultural Society at Charleston. A few happy essays confirmed him in his opinion, but his return to Europe did not permit him to continue his former attempts. On my arrival at Carolina I found in this garden a superb collection of trees and plants that had survived almost a total neglect for nearly the space of four years. I likewise found there a great number of trees be-

*Travels to the West of the Alleghany Mountains, in the States of Ohio, Kentucky, and Tennesse, and back to Charleston by the Upper Carolinas. London, 1805.

longing to the old continent, that my father had planted, some of which were in the most flourishing state. I principally remarked two ginkgo bilobas, that had not been planted above seven years, and which were then upward of thirty feet in height; several sterculia platanifolia, which had yielded seed upward of six years; in short, more than a hundred and fifty mimosa illibrissin, the first plant of which came from Europe about ten inches in diameter. I set several before my return to France, this tree being at that time very much esteemed for its magnificent flowers. The Agricultural Society at [sic] Carolina are now in possession of this garden: they intend keeping it in order, and cultivating the useful vegetables belonging to the old continent, which, from the analogy of the climate, promise every success. I employed the remainder of the autumn in making collections of seed, which I sent to Europe; and the winter, in visiting the different parts of Low Carolina, and in reconnoitering the places where, the year following, I might make more abundant harvests, and procure the various sorts that I had not been able to collect during the autumn."

The "ginkgo bilobas" (Ginkgo biloba)* trees here mentioned are undoubtedly the ones seen by Judge Smith on one of his first visits, but they have now disappeared.

The Ginkgo is one of the most unique of living trees. The leaves have the shape and texture of the leaflets of the maidenhair fern, and for this reason it is often called the "Maidenhair tree." While the general effect of the Ginkgo is more like that of the broad-leafed trees (Angiosperms), we know from botanical evidence that it is even more primitive than the pines. It is a native of China, but grows well in America and is often planted for ornament.

The two other trees mentioned in the quotation above have now become extensively cultivated in the Southern states. The Sterculia or Varnish Tree is an exotic-looking species (native of China), with very large leaves. It has the remarkable habit of maturing its seeds on the exposed edges of the open carpels, The "mimosa" (now known botanically as Albizzia Julibrissin)

*Or *Salisburia adiantifolia*, another name.

is one of the few hardy members of its group, and is the small spreading tree with pretty pink flowers so often seen in Southern lawns and parks. It is the only one of the three trees referred to above that is still to be seen at the old garden.

In order to see the present condition of the garden I visited Charleston early in June of last year (1910) and went out to Ten Mile Station. On getting off the train the fine grove of broad-leaved trees that marked the site of Michaux's house was in full view about one-half mile farther up the track, and about 400 yards north of it. The grove is bordered on the east by a field, on the north by an even second growth forest of old-field pine (Pinus Taeda), on the west by the narrow swamp of a branch, and on the south by bushy cleared land through which runs the branch. As I approached the place one of the first things to attract my attention was a tree of the "mimosa" mentioned above. It was in full bloom and stood near the branch about half way between the grove and the railroad. In the field to the southeast of the grove is an immense old Magnolia grandiflora which was almost certainly planted by Michaux himself in what was then the nursery. A photograph was taken of this tree, as shown in Plate II. It is unusually wide spreading for a magnolia, and is one of the most impressive specimens I have ever seen.

Approaching about one hundred yards nearer the edge of the grove I took the photograph shown in Plate III. Magnolias appear on each side and oaks in the center. Within the grove the interwoven boughs cast a dense shade and all the trees are densely hung with long gray "moss" (Tillandsia usnioides). A picture was taken here under the trees and it shows well the dense moss and the low hanging boughs of the live oaks (Plate IV). Near the center of the grove, about 150 feet north of where this photograph was taken, stood the old house, and its position is still distinctly marked by several piles of broken bricks. Immediately in front of the house are three very old live oaks (Q. virens), one of which has recently been blown down. The other two are apparently from the same root, and are now on the decline.

A few feet from the west side of the house stands a very fine old specimen of the southern sugar maple (Acer floridanum), which was undoubtedly planted here, as the tree does not grow naturally in such situations around Charleston. So far as known it does not approach nearer Charleston than the headwaters of the Cooper River, thirty miles away (Elliott). About five other good sized specimens of this species are grouped in the grove to the southwest of the house, and a number of much smaller ones are coming on as seedlings from the old trees.*

About sixty feet west of the house stand, close together, two magnificent old cedars that certainly reach back to Michaux's time, if not earlier. Draped with "moss" and perfect in every way, they are the most impressive specimens I have ever seen. Other trees of the grove are a large number of fine magnolias, live oaks, and water oaks (Quercus nigra L.), two very old red birches (Betula nigra), and a large number of smaller seedlings from them, a few post oaks (Quercus stellata), black oaks (Quercus velutina), choke cherries (Prunus serotina), Carolina laurel-cherries or "mock orange" (Prunus caroliniana), white hickories (Hickoria alba), and sweet gums (Liquidambar styraciflua). There was considerable undergrowth of dog-wood (Cornus florida), holly (Ilex opaca), waxberry (Myrica cerifera), possum-haw (Viburnum nudum), Jersey tea (Ceanothus americanus), white-leaved blackberry (Rubus cuneifolius), dewberry (Rubus trivialis), red buckeye (Aesculus Pavia), and bear grass (Yucca filamentosa). A rather extensive clump of hazel nut (Corylus americana) was flourishing under the live oaks. It was probably planted by Michaux. The vines, which were quite abundant in the shrubbery, were four species of catbrier (Smilax glauca, S. bona-nox, S. lanceolata, and S. rotundifolia), Summer grape (Vitis aestivalis), Virginia creeper (Ampelopsis quinquefolia), and poison ivy (Rhus Toxicodendron). Near the two old cedars I was surprised to see two plants of gladiolas, one in fine bloom. It is surprising that they should have survived so long in utter neglect.

On the gentle sandy slope between the grove and the branch was a fine carpet of ferns and flowers under some large

*This species is native as far up as Chapel Hill, N. C.

trees of pines, oaks and gums. The ferns here were cinnamon fern (Osmunda cinnamomea), royal fern (Osmunda regalis), bracken fern (Pteris aquilina), chain fern (Woodwardia areolata), large chain fern (Woodwardia virginica), and lady fern (Asplenium Felix-femina). In damper places among the ferns were in bloom the pretty pink orchid (Calapogon pulchellus) and the blue skull cap (Scutellaria integrifolia), and higher up among the bracken there were conspicuous purplish patches of Samson's snakeroot (Psoralia pedunculata) and the scattered white spikes of star grass (Aletris farinosa). The white flowers of daisy fleabane (Erigeron ramosus) were abundant under the pines.

In the rich and more or less swampy soil along the branch were Cypress (Taxodium distichum), black gum (Nyssa sylvatica), Southern red maple (Acer carolinanum),* sweet gum (Liquidamber styraciflua), old field pine (P. Taeda), long-leaf pine (P. palustris), short-leaf pine (P. echinata), sweet bay (Magnolia glauca), alder (Alnus rugosa), possum haw (Viburnum nudum), pepper bush (Clethra alnifolia), candleberry (Myrica cerifera), and swamp azalea (Azalea viscosa). Climbing up the trees was the very attractive and interesting vine Decumaria barbata, belonging to the hydrangea family. It has much the same habit as the English ivy, attaching itself to the bark of the trees by adventitious roots and sending off horizontal flowering branches at some distance from the ground. I have tried to cultivate this vine in the arboretum of the University of North Carolina at Chapel Hill, but have not succeeded in getting it to live for more than two or three years.

When we consider the number of times that Michaux's garden property has changed hands, it is surprising that the old grove has remained so completely undisturbed. It is hardly likely that this immunity has been due to sentiment, even though the historic associations of the spot have not been forgotten entirely, and unless acquired and protected by some interested organization the grove may at any time be felled and the living record of a great man lost forever.

Chapel Hill, N. C.

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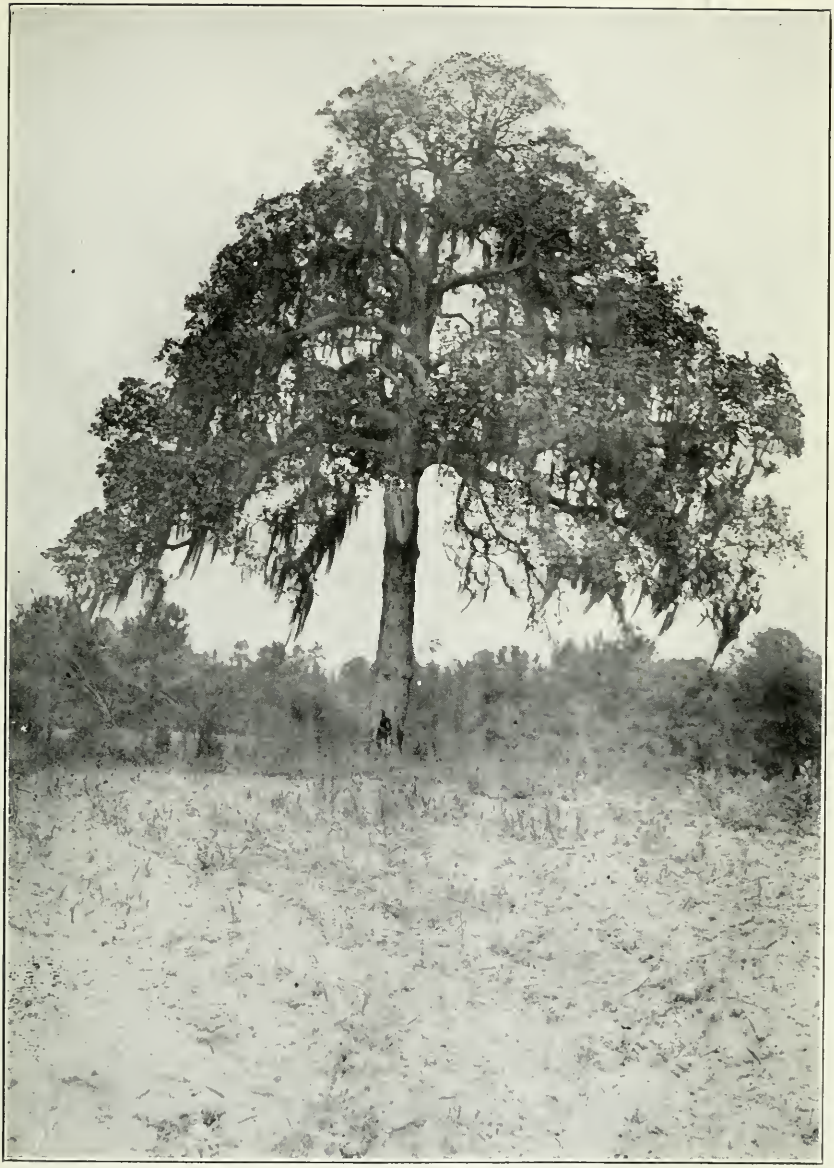
*From my observation this form seems to intergrade imperceptibly into the typical *Acer rubrum*.

Plate II.



OLD MAGNOLIA
MICHAUX'S GARDEN

# PROCEEDINGS OF THE TENTH ANNUAL MEETING OF THE NORTH CAROLINA ACADEMY OF SCIENCE.

HELD AT THE AGRICULTURAL AND MECHANICAL COLLEGE, RALEIGH, N. C., APRIL 28-29, 1911.

The Executive Committee met at 2:45 p. m., Friday, April 28, there being in attendance Pres. W. H. Pegram and Sec'y-Treas. E. W. Gudger ex-officio, and F. L. Stevens. In addition, C. S. Brimley and Franklin Sherman, Jr., were asked to act for H. H. Brimley and H. V. Wilson, absent. The Sec'y-Treas. read his report, which showed that in addition to the usual routine work, the Constitution and By-Laws have been edited and published with a list of the officers from date of organization and the roster of members revised to Jan. 1, 1911. The membership for 1909 was 44; new members added in 1910, 46; actual membership Jan. 1, 1911, 90. The following new members were then elected:

Dr. W. T. Carstarphen, Prof. of Physiology Wake Forest College.

Mr. W. T. Harding, 116 W. Jones St., Raleigh.

Prof. W. P. Jackson, Instr. in Science, High School, Raleigh.

Dr. Wm. de B. MacNider, Prof. of Pharmacology, Univ. of N. C., Chapel Hill.

Mr. W. C. Norton, Asst. in Botany, A. & M. Collge, W. Raleigh.

Mr. G. W. Wilson, Asst. Plant Pathologist, A. & M. College, W. Raleigh.

There was then laid before the Committee the offer of the Journal of the Elisha Mitchell Scientific Society with regard to publishing the proceedings. Heretofore, when the Academy numbered 40-50 members, the charge has been $50.00. Now that the membership has doubled, the new offer is to publish the proceedings and any papers presented at the annual meeting, and furnish the Journal to each member of the Academy (the number not to exceed 100) for $75.00 per year, to take effect for the year 1910-11.

The Secy. offered a resolution that hereafter each member when sending in his titles for the yearly meeting specify the amount of time wished, and that this be printed in the program. The following by-law was proposed by Franklin Sherman, Jr.:

BY-LAW 6.

> The Secretary-Treasurer, during his term of office, shall not be liable for annual dues, and his necessary expenses in attending the regular meetings shall be defrayed from the Treasury of the Academy.

All these matters were favorably recommended to the Academy.

The Treasurer's report for 1910-11 showed:

RECEIPTS

| | |
|---|---|
| Balance from last audit | $167 29 |
| Dues paid | 92 00 |
| Interest on Savings Bank Deposit | 4 93 |
| Total receipts | $264 22 |
| Expenditures | 80 64 |
| Balance | $183 58 |
| Savings Bank balance | $133 29 |
| Checking account | 50 29 |
| Total in Bank | $183 58 |
| Uncollected dues | 29 00 |
| Estimated resources | $212 58 |

EXPENDITURES

| | |
|---|---|
| Printing | 15 50 |
| Proceedings (Mitchell Journal) | 50 00 |
| Typewriting | 8 00 |
| Postage and Express | 7 14 |
| Total expenditures | $ 80 64 |

OUTSTANDING DEBTS

| | |
|---|---|
| Proceedings, 1910-11 | $ 75 00 |
| Miscellaneous (about) | 8 00 |
| Estimated debt | $ 83 00 |

At 3 p. m. Pres. Pegram called the Academy to order and appointed the following committees:

*Nominating* — C. S. Brimley, W. C. Coker and Julian Blanchard.

*Auditing* — J. J. Wolfe, R. I. Smith and F. Sherman, Jr.

*Resolutions* — Collier Cobb, C. B. Markham and A. H. Patterson.

Then followed the reading of papers in order as shown on the following program, adjournment taking place at 5:45, when twelve numbers had been called.

On reassembling at 8:30 p. m. the Academy was warmly welcomed to the A. & M. College by Pres. D. H. Hill. After making response to the address of welcome, Pres. Pegram delivered the Presidential Address on the subject, "The Problem of the Constitution of Matter." Following him, Prof. John F. Lanneau delivered a lecture on "Sirius, the Bright and Morning Star." After adjournment, the Committee on Science Teaching in the Schools of North Carolina (W. C. Coker, chairman) held a meeting.

At 9 a. m., Saturday, the Academy reconvened in annual business meeting. The three recommendations of the Executive Committee were unanimously adopted. The Nominating Committee reported as follows:

For officers for 1911-12 — Pres., Dr. H. V. Wilson, Prof. of Zoology, Univ. of N. C., Chapel Hill; Vice-Pres., Prof. W.

A. Withers, Prof. of Chem., A. & M. College, W. Raleigh; Secy-Treas., Dr. E. W. Gudger, Prof. of Biology and Geology, State Normal College, Greensboro.

Executive Committee — Dr. J. J. Wolfe, Prof. of Biology, Trinity College, Durham; Mr. F. Sherman, Jr., Entomologist, Dept. of Agriculture, Raleigh; Prof. A. H. Patterson, Prof. of Physics, Univ. of N. C., Chapel Hill.

The Committee on Resolutions reported as follows:

*Resolved,* That the North Carolina Academy of Science extend to President Hill and the Faculty of the N. C. College of Agriculture and Mechanic Arts its appreciation of the hearty welcome and hospitality extended to it.

That we express to the *News and Observer* and the *Evening Times* our thanks for the publication of the program and for the excellent reports of the proceedings of the Academy.

Prof. W. C. Coker, Chairman of the Committee on Science Teaching, gave an outline report on Science teaching in the State and discussed the situation. On motion the committee was authorized to complete its report and publish it on the authority of the Academy.*

At 10 a. m., by special invitation, Dr. R. A. Hall, of the Univ. of N. C., read his report, "The Chemical Researches of Ehrlich Leading to '606'" before a joint meeting of the Academy and the N. C. Section of the American Chemical Society. Next came the reading of the Chemistry papers on the program of the Academy—these having been made a special order for this hour—followed by the regular program. The reading of papers having been concluded at 2 p. m., the Academy adjourned to the dining hall of the College and was there entertained at luncheon by the College and by the Raleigh members.

The following members were in attendance: Blanchard, J.; Brimley, C. S.; Bruner, S. C.; Chrisman, W. G.; Clapp, S. C.; Cobb, Collier; Coker, W. C.; Edwards, C. W.; Gudger, E. W.; Herty, C. H.; Hutt, W. N.; Hutt, Mrs. W. N.; Ives, J. D.; Jackson, W. P.; Kilgore, B. W.; Lanneau, J. F.; Lay, G. W.; Lockhart, L. B.; Mac-

*This report will appear in full in the North Carolina High School Bulletin for July, 1911.

Nider, G. M.; Markham, C. B.; Metcalf, Z. P.; Metcalf, Mrs. Z. P; Mills, J. E.; Newman, C. L.; Norton, W. C.; Patterson, A. H.; Pegram, W. H.; Pratt, J. H.; Shaw, S. B.; Sherman, Franklin, Jr.; Shore, C. A.; Smith, R. I.; Stevens, F. L.; Williams, L. F.; Wilson, G. W.; Wilson, H. V.; Wilson, R. N.; Withers, W. A.; Wolfe, J. J.

The total attendance was 40 out of a membership of 85. There were 33 papers on the program, all of which were read but two, and all when called for save two. In attendance, number of papers, range of discussion, and general interest, this session exceeded any in the history of the Academy.

In addition to the presidential address (published in full in this issue), and to the lecture on "Sirius," the following papers were presented:

*Catching Hawk Moths on Flowers at Dusk,* C. S. Brimley, Raleigh.

[Published in full in this issue.]

*Natural History Notes,* E. W. Gudger, State Normal College, Greensboro.

A. An Interesting Case of Symbiosis. (Specimens exhibited.)

For six successive seasons, wood frogs, leopard frogs, toads, and salamanders (species unknown, probably *Amblystoma punctatum*), have been observed to lay their eggs in a small pool in the college park. Each spring it has been noted that the eggs of the salamanders only had a greenish color. Microscopic examination shows that this is due to great numbers of a very small unicellular green alga found within the inner mass of jelly. The green color grows more marked as the development of the eggs takes place, due presumably to the larger amount of $CO_2$ given off as the larvæ become more active. Since no algae have ever been found in the outer or general mass of jelly, it seems possible that they may penetrate the oviducts of the salamander and become enclosed in the inner capsule of jelly as the eggs pass to the exterior.

B. Some Plant Abnormalities

A bifurcated frond of the common Boston Fern was exhibited. This was one of two growing on one plant in the writer's laboratory at the present time. Three years ago two others were noticed on different plants.

A drawing was exhibited of a motile Haematococcus with four flagella. This was found last fall in a lot of fresh material from a cemetery urn.

*Results of a Practical Attempt to Control Lettuce Sclerotiniose,* F. L. Stevens, A. & M. College, W. Raleigh.

Lettuce sclerotiniose has been the subject of investigation for several years in the North Carolina Agricultural Experiment Station. From the laboratory study it was concluded that all structures except the sclerotium are short lived; therefore, that if the formation of new sclerotia could be prevented diseased beds could eventually be restored to health. To test this theory several experimental beds were very thoroughly infected in April, 1908, by heavily inoculating a large number of plants and allowing the sclerotia which were formed to remain in the beds. The following year 555 plants, or over 45 per cent., died of sclerotiniose. From this time on a course of treatment designed to prevent the formation of sclerotia was followed with the hope of lessening the disease. The following year only seven plants, or one-half of one per cent., of the crop died. A year later, that is, the present year, the results were almost the same. This experiment seems to indicate that control of this disease can be obtained by the methods employed.

*Some Points of Architectural Acoustics,* Andrew H. Patterson, University of North Carolina, Chapel Hill.

An account of experiments made by the author and Mr. A. L. Feild on the acoustics of Memorial Hall at the University of North Carolina. The reverberation in this hall is very bad, and the problem is complicated by bad echoes due to large flat panels in the dome-shaped ceiling. Further experiments will be undertaken in an attempt to find a complete solution of the difficulty.

*Preliminary Report of the Regeneration of Nemerteans and Amphitrite,* Judson D. Ives, Wake Forest College, Wake Forest.

Sections of Nemerteans were found to regenerate readily. The anterior surfaces of the sections regenerated but a small amount of new material compared to that formed by the posterior surfaces. A small section, 1.2 cm. long, regenerated 2.5 cm. on its posterior surface in twenty-five days. Another section, 0.8 cm. in length, regenerated 1.6 cm. in the same length of time. A section 2.1 cm. regenerated 1.5 cm. in twenty-five days. A section 8.3 cm. long regenerated 0.6 cm. in twenty-nine days. A worm with its posterior portion cut off, its head and the remaining anterior portion measuring 10.2 cm., regenerated 1 cm. in twenty-nine days.

In Amphitrite the tentacles were found to regenerate readily and rapidly. A large per cent. of worms with the portion in front of the branchiae removed, along with their tentacles, lived for eleven to fourteen days when they were killed for preservation.

A worm with five branchiae cut off thereby leaving but one branchia uninjured, lived for eleven days.

Worms with the portion in front of the second pair of branchiae removed, thereby removing the tentacles and the first pair of branchiae, lived for thirteen days, and were in good condition when killed.

A very few worms which had their entire heads cut off back of their branchiae lived for four days.

A large per cent. of worms which had about a third of their posterior portion removed lived for fourteen or fifteen days, and were in very good condition when they were killed.

*A Dangerous Apple Disease,* F. L. Stevens and Guy West Wilson, A. & M. College, West Raleigh.

This disease came to our notice in 1909, from Lincoln County, where it appeared in 1908 on a single tree, and despite the cutting out of all disease seen and spraying with lime-sulphur, it spread the next year to 13 trees. The same trouble appeared in Sampson County in 1909 with even more disastrous results.

Whitish or pinkish pustules appear on the younger twigs and about the crotches of the tree. These bear numerous spores of the Fusarium or tubercularia type, but so far no ascigerous form has been connected with them. The infection is in the bark, the diseased areas shriveling and separating. The epidermis splits away exposing the browned surface beneath, or the pustules merely break through the epidermis, especially near the lenticels. Upon older twigs the bark cracks longitudinally, exposing rows of pustules in the cracks. A pinkish mycelial growth sometimes appears on the diseased twigs.

*Condimental Feeds, Stock and Poultry Tonics and Conditioners,* G. M. MacNider, Department of Agriculture, Raleigh.

The legislature of 1909 passed an act requiring all manufacturers of condimental, patented, proprietary or trade-marked stock or poultry tonics, regulators or conditioners to register with the Commissioner of Agriculture each brand offered for sale in the State and to pay an annual license fee of twenty dollars for each brand.

This law covers such preparations as Pratt's Conditioner, Prussian Stock Tonic, Capitol Stock Remedy, International Stock Food, Magic Poultry Tonic and many others.

During the year 1910 sixty-three brands were registered in accordance with this law. Of this number forty were preparations claiming to be of medicinal value for stock, eighteen were for poultry and five were preparations claiming to be of value for stock and poultry.

Under the authority of this law the author has analyzed chemically and microscopically sixty-four of these proprietary remedies. The results of this work have recently been published in a bulletin of the N. C. Department of Agriculture.

These preparations are usually composed, largely, of a base material such as wheat bran, middlings, oil meal, cotton-seed meal, corn meal, etc. To this are added a large variety of both mineral and vegetable drugs. Some of the preparations contain only two or three ingredients, while others contain twelve or

PLATE III.

OLD GROVE
IN MICHAUX'S GARDEN

fifteen drugs in addition to the base material. Salt, sulphur, charcoal, fenugreek, Epsom salts, and ginger are the drugs most frequently found. Thirty-four drugs were found in the preparations examined. The drugs which are used in any considerable amount in the preparations are of practically no value in veterinary medicine, while the drugs which are of value are present in such small amount that they can have no effect.

A number of experiment stations, both in this country and abroad, have conducted feeding experiments, with different classes of animals and poultry, to determine the actual value of these preparations. In no instance has the use of proprietary remedies proved to be of value for either stock or poultry. As before stated, the drugs are present in such small quantity that they are useless in the treatment of disease.

It is safe to conclude that this class of preparations are high priced fakes which should be carefully avoided by every one interested in either stock or poultry.

*The Turkey Buzzard Must Go,* George W. Lay, St. Mary's School, Raleigh.

[Published in full in this issue.]

*The Library of Congress as an Aid to Scientific Research,* E. W. Gudger, State Normal College, Greensboro.

The Library of Congress, with its vast aggregations of books and journals, including the priceless Smithsonian collection, is the greatest aid in America to the historical side of scientific research. Through the system of inter-library loans, nearly any and all of this enormous mass of literature is available to the scientific researcher, provided that his college library bear the cost of transportation. The writer has during the past five years carried on three separate extensive historical researches in ichthyological literature which would have been impossible without access (at a distance) to this great library. It is a pleasure to record the prompt and efficient service with which every one of the many requests for books has been met, and to call the attention of scientific men to this great adjunct to their work.

*Occurrence of the Yellow Fever Mosquito at Raleigh,* C. S. Brimley, Raleigh.

Several years ago I noticed that occasionally mosquitoes would bite in the afternoon, long before sundown, and caught one of them, which on examination I concluded to be the Yellow-fever Mosquito (Stegomyia calopus), but did not feel absolutely certain.

Last year however during August and September, I noticed a good many mosquitoes to be active and biting in the house during all parts of the day, even at noon. I took occasion to catch quite a number of them, and with the help of Mr. Z. P. Metcalf of the N. C. Dept. of Agriculture succeeded in conclusively identifying them as the Stegomyia calopus.

These mosquitoes were active during the greater part of the day, except possibly the early morning, at which time I do not remember noticing any, and would come around one even on the hottest days at noon. Their hum seemed quite distinctive, being to my mind more nervous and quicker than that of the commoner species, giving one more the impression that the insect had somewhat lost its temper. In appearance they are rather small mosquitoes with the legs conspicuously banded with several bands of white, there is also a silvery lyre shaped mark on the upper part of the thorax, this latter however is easily rubbed off in capturing the insect, which is a pity as it is the most distinctive color mark of the species.

I did not succeed in finding out where the Stegomyia bred, although I tried to find some place where the larvae might possibly be found.

Mosquitoes caught after dark during the same period were usually, and if I remember correctly always, other species.

The species has not been noted by the few other entomologists, who live in other portions of Raleigh.

*Proposed Reform in Our Calendar,* Andrew H. Patterson, University of North Carolina, Chapel Hill.

A discussion of the various methods proposed in recent years for the reform in our present calendar.

*Conjugating Yeasts,* W. C. Coker, University of North Carolina, Chapel Hill.

In the course of experiments by an advanced class in the fall of 1910 the rare and peculiar wild yeast, *Schizosaccharomyces octospora Beyerinck* was found. It appeared in test tubes that were filled with distilled water in which were a number of unbroken Delaware grapes that were bought in the local market. A day or two after the tubes were prepared a slow fermentation set up, and later a precipitate appeared. On examination of this precipitate after three weeks it was found to contain the *Schizosaccharomyces* in process of conjugation. A later experiment made with Tokay grapes gave a similar result. Cultures were continued and the life history studied in all stages, confirming in general the observations of Guilliermond. Four species of *Schizosaccharomyces* are known, all supposed to be tropical or sub-tropical, and *S. octospora* has been known heretofore only from Greece.

*Some Interesting Water Molds,* W. C. Coker, University of North Carolina, Chapel Hill.

The occurrence in Chapel Hill of *Thraustotheca clavata (DeBary) Humphrey* was reported. It seems to have been found previously only at Strassburg, Germany. In this singular mold the sporangial wall dissolves away almost completely, suggesting the method of spore liberation in Rhizopus, and the encysted spores are allowed to fall apart in all directions. The spores escape from their cysts in the laterally ciliated form, showing that the first swimming stage is suppressed.

There also occurs in Chapel Hill a species of *Dictyuchus* in which the entire sporangium breaks away from the hypha as soon as the spores become distinct. After some time the spores escape singly through individual tubes as is normal in the genus.

Other points reported were the appearance of a variety of *Achlya americana* with hypogynus tubes, the occurrence in Chapel Hill of *Achlya racemosa Hildeb,* and the fact that *Saprolegnia diclina Humphrey* is at least not always dioecious.

*Rhizoctonia of Buckwheat,* F. L. Stevens and G. W. Wilson, A. & M. College, West Raleigh.

Mention was made of a serious outbreak of rhizoctoniose on buckwheat in the western part of North Carolina.

*The Finned-Tailed Larva of the Butterfly Ray, Pteroplatea Maclura,* E. W. Gudger, State Normal College, Greensboro.

The adult ray has a very short tail, in length about equal to one-third of the body, with very faint traces of dorsal and ventral finfolds. A photograph was exhibited of three young attached to flattened yolks, showing each embryo with a profusion of long external gills and a tail three-fourths as long as the body. All three larvae have the hinder halves of their tails distinctly finned above and below, thus forming broad paddle-like organs. The significance of this in the phylogenetic history of this ray is very great.

More than half the material is at hand for the embryology of the fish, and an effort will be made to collect the remaining stages this season.

*The Present Status of the Relativity Principle,* C. W. Edwards, Trinity College, Durham.

The Principle of Relativity as developed by Einstein is expressed in the terms of two postulates—one introducing primarily the idea of the relativity of motion and the other depending rather more upon the relativity of time. The first postulate has been accepted since the time of Newton and may be formulated as follows: Absolutely uniform translatory motion can neither be measured nor detected. Another statement is that any observed motion, when referred to a definite system of coordinates, is dependent on the velocity of the origin of coordinates.

The second postulate states that the velocity of light is independent both of the observer and of the source. This is a pure assumption so far and is not in entire harmony with the first postulate. In fact the experiments of Michelson and Morley, as well as those of Trouton and Noble, seem best explained by the opposite assumption that the velocity of light is *not* independent of its source. These experiments may also be explained on the basis of the assumption of Lorentz. The electro-magnetic theory adapts itself wonderfully to the second postulate while the electromagnetic emmission theory of J. J. Thomson adapts itself to the opposite hypothesis. So long as we confine ourselves to a consideration of uniform motion, the integrity of our present system of mechanics is maintained. There is nothing inconsistent in the ideas of kinetic length (Lorentz), and kinetic mass (Kaufmann and Bucherer).

The battle is at present being waged around the second postulate. Either the acceptance of a stationary ether, or of a moving ether, or the entire denial of the existence of an ether will be the outcome.

*The Whistling Arc in the Study of Auditorium Acoustics,* C. W. Edwards, Trinity College, Durham.

Employing the well known device of using a sound emitting light for a source of sound waves, a whistling arc was used for investigating confusion and distorsion in an auditorium. The very large variety of sharp clear notes that the arc could be made to emit by varying the inductance made it especially useful in the study of the less practical problem of distorsion. Small mirrors were used, following the method of F. R. Watson of the Univ. of Ill., to trace the path of the sound waves after reflection from various surfaces.

*Survivals Along the Sea Islands From Hatteras to Key West,* Collier Cobb, University of North Carolina, Chapel Hill.

*The Peat Deposits of North Carolina,* Joseph H. Pratt, Chapel Hill.

*Isoetes in North Carolina,* W. C. Norton, A. & M. College, West Raleigh.

*The Composition of Melted Kauri Copal, as Used in Varnish Making,* Charles H. Herty and C. S. Venable, University of North Carolina, Chapel Hill.

*A Bacteriological Soil Survey of North Carolina,* F. L. Stevens and W. A. Withers, A. & M. College. Presented by W. A. Withers.

*Results of Some Preliminary Studies in Wing Vein Homologies, Homoptera Cicadina (Lantern)*, Z. P. Metcalf, Department of Agriculture, Raleigh.

*Regressive Differentiation in Hydroids and Sponges,* H. V. Wilson, University of North Carolina, Chapel Hill.

*A Striking Class-Room Experiment After Otto Von Guericke* (by invitation), J. M. Pickel, Department of Agriculture, Raleigh.

*Recent Changes of Level from Cape Hatteras to Cape Sable (Lantern)*, Collier Cobb, University of North Carolina, Chapel Hill.

*How to Discover the Solution of a Problem,* John F. Lanneau, Wake Forest College, Wake Forest.

*Mineralogical Notes on Rutile, Prophyllite, Talc and Graphite,* J. H. Pratt, Chapel Hill.

*Some Interesting Variations in the Flowers of a Local Vinca,* W. C. Norton, A. & M. College, West Raleigh.

*Road Surfacing Materials,* Joseph H. Pratt, Chapel Hill.

*Some Seedlings of the Scuppernong Grape* (by invitation), F. C. Reimer, Department of Agriculture, Raleigh.

E. W. GUDGER, *Secretary.*

# THE PROBLEM OF THE CONSTITUTION OF MATTER.*

By W. H. Pegram,

What is matter? Is the world made of one substance, or of many substances? Such questions have puzzled the minds of men from the earliest times, and the quest for knowledge of the ultimate has been a fundamental characteristic of all systems of philosophy and science. With Parmenides matter is simply not being as opposed to being. Plato attributed to matter something more than mere negative existence. With him it is the correlate of idea. Aristotle regarded it as pure potentiality and utterly devoid of determination. Bishop Berkeley denied the existence of matter altogether, as did Lotze of our day. As opposed to the idea of the absolute continuity of matter as proposed by Anaxagoras, Democritus advanced the theory of the atom, that has been held in some form to the present time. The Democritan atom had many sizes, shapes and aggregations, which differences constituted the differences of material objects. The famous vortex rings of Helmholtz were imagined by Lord Kelvin to be the true form of the atom—the vortices being set up in the ether. Boscovitch held rather vaguely that the atom is merely a center of force. All views of this type were unprofitable and incapable of meeting the demands of experimental science.

The modern scientific idea as to the structure of matter had its origin in Dalton's Atomic Theory. His conception that the chemical elements are divisible into atoms is well crystallzed in the mind of every student of science. But what scientific evidence have we of the existence of atoms and molecules as real and definite divisions of matter? The evidence is both inferential and direct. The whole of chemistry, most of physics, and a large portion of the natural sciences may be regarded as constituting a body of inferential evidence in support of the Atomic Theory.

*Presidential Address before the North Carolina Academy of Science, April 28, 1911.

Of direct evidence one of the most striking examples is the Brownian movement, an adequate explanation of which has been given in the last few years. A naturalist, Brown, in 1827, observed with the microscope that fine particles of solid matter suspended in a liquid exhibit a state of rapid and perfectly irregular movement, reminding one of "a swarm of dancing gnats in a sunbeam." He proved that the movement was not due to animalculae, and recognized that the smaller the particles the more rapid the movement. Recently, Zsigmondy and Einstein have carefully investigated the whole matter with the aid of the marvelous ultra-microscope, and have developed the theory that a small particle shares in the molecular motion of the surrounding liquid, and that except as to size there is no essential difference, from the standpoint of the molecular theory of heat, between a particle suspended in a liquid and a molecule in solution. This Brownian movement varies with the temperature — the particles moving more rapidly as the temperature increases — and varies in just the way that the kinetic molecular theory predicts. Moreover, the suspended particles exert an osmotic pressure, as direct experiment has shown: so they behave in this respect just as molecules in solution. The ultra-microscope shows the exceedingly small particles as bright specks in the otherwise dark field; just as we see dust particles when looking across a beam of light in a darkened room. As one looks upon the erratic movement of the particles he realizes that he is *seeing* molecular motion — or at least the direct result of it — at first hand.

Going further than this Rutherford in a classic experiment actually counted the atoms, one by one. He not only proved that the ballistic jump of the electrometer corresponds closely to the flashes of light in the spinthariscope, not only that the gas helium exists in extraordinarily small particles, but that these particles which he counted were actually *helium atoms*. In a recent experiment at the University of Chicago Prof. R. A. Millikan succeeded in isolating the individual ion, moving it about and examining it at will.

Now contemporaneously with the development of the modern idea of the atom there developed also the idea that the atom does not represent the ultimate stage or limit in the subdivision of matter. Dalton's atomic theory was placed on record in 1803. Only twelve years later (1815) Dr. Prout published his observation that the atomic weights of all the other elements are approximately and in many cases exactly integral multiples of the atomic weight of hydrogen, and on this observation based the hypothesis that hydrogen alone is elementary — that it is the primordial substance — and that the atoms of all the other so-called elements are aggregations of hydrogen atoms. This hypothesis persisted for fifty years with fluctuating fortune; and though it was finally abandoned, its career was attended by many collateral advantages to the scientific world. It had accustomed men to think of the possible complex nature of *all* atoms; it had prompted successive and more refined re-determinations of the atomic weights; and it had stimulated many distinguished chemists to inspect closely and persistently the tables of atomic weights for the purpose of discovering (if possible) numerical relations between these atomic weights as evidence of relations between the elements themselves. The result of this half century of work inspired by Prout was crystallized by Mendelèef, who published in 1869 a crude form of the Periodic arrangement of the Elements, and the announcement of the celebrated Periodic Law, that the properties of the elements are functions of their atomic weights. Scientists claimed at once that this law, if true, represents only a superficial truth. If the elements be thus related, they must be composite, or in some deep-seated way have a common bond or a common origin.

From 1870 to 1895 there was obtained no scientific evidence in support of this conclusion. Men talked and wrote freely of the possible genesis of the elements through a process of successive condensation of some superheated primordial stuff, and of the possible disintegration of the atoms of the Elements by means of high temperatures. Sir Norman Lockyer's ambitious effort to obtain scientific proof of this hypothesis by means of spectroscopic observation of the condition of the matter on the sun and stars promised much, but yielded nothing. Many modifications of Mendeleèef's arrangement of the atomic weights were offered, and many revisions of the hypothesis as to the genesis or evolution of the elements were advanced. The literature of the period shows great intellectual activity in this fascinating field; but no clearer vision of the nature of the atom and of the supposed sub-atom's states of matter was attained.

Thus for twenty-five years the assault continued without any material advancement of the firing line. The atom stood intact and apparently impregnable. Suddenly, however, in a brief period beginning with 1896, a perfect flood of light was thrown on the question. Phenomena connected with the origin and polarization of light waves, the investigation of the conduction of electricity through gases, the properties of electric waves, and the properties or radio-active matter and related facts, constituted an epoch of conquest unparalleled in the history of science. In this brief period a new branch of science has been created, rich in phenomena of the most striking sort. A much better interpretation of phenomena already known, a vastly stronger theory as to the structure of matter and a firmer coordination of all physical phenomena have been attained. The character of this new knowledge and the methods by which it has been obtained may be briefly stated as follows:

In 1896 Zeeman, by his celebrated experiments confirmed in an astonishing degree the theory of Lorentz that light of different wave lengths from an incandescent gas proceeds not from vibrating atoms, but from electrified particles associated with the atoms. Subsequently by appropriate qualitative and quantitative experiments these electrified particles were found to carry a unit negative charge and to have a mass one-thousandth that of the hydrogen atom.

The well known Cathode rays were re-investigated by Thomson and others, who found that these rays consist of electrified particles projected from the Cathode with a velocity of 1-20 to 1-10 that of light; that the charge carried by each particle is a unit of negative electricity; that the mass of each particle is one-thousandth that of the hydrogen atom; and that the particles derived from one substance are identical in mass and charge with particles derived from any other substance.

In the experimental study of the conduction of electricity through ionized gases it was found that the particles carrying negative electricity are the same in all gases, and that they are identical in mass and charge with the particles of the Cathode rays.

In the field of radioactivity we are familiar with the fact that radioactive bodies emit or discharge electrified particles of two grades, known as the $\alpha$ rays and the $\beta$ rays (the $\gamma$ rays are of a different order, and need not be noticed further). Repeated experiments show that $\alpha$ rays consist of positively charged particles, each having a mass not less than the hydrogen atom; and that the $\beta$ rays consist of negatively charged particles, identical in mass and charge with the particles of the Cathode rays.

Thus by unquestioned experimental evidence derived from four fields of investigation, three facts of fundamental importance have been established: (1) The existence of particles of matter much less than the smallest atom; (2) These sub-atomic particles, though derived from different kinds of matter, are identical in mass; (3) Each particle invariably carries a unit charge of negative electricity. Here then is the sub-atom, having a mass one-thousandth that of the hydrogen atom, derivable from the atoms of the various elements; a common ingredient then of all atoms, a universal constituent of matter. At last the atom — the late indivisible unit of matter — has been divided, and the persistent mystery of 70 or 80 primordially different kinds of matter has been solved. This new unit of matter — the sub-atomic mass with its negative charge — takes its place in the order of scientific truths. It is the "Corpuscle" of Thomson, the "Electron" of other writers.

In the light of the above facts what shall be our conception of the structure of an atom? Making use of what is known, and not incorporating hypothetical elements, we may think of an atom as a number of electrons arranged about a central mass charged with positive electricity. In the normal state of matter the positive and negative charges of electricity within the atom are in a condition of equilibrium; but in an abnormal state — a state of electrification — this equilibrium is disturbed and both positive and negative electricity are manifested. This view of the atom permits the explanation of phenomena in terms of matter and electricity with emphasis on the former. Matter with its inherent property of mass, or inertia, still retains its primacy, with electricity as an attribute of matter.

We now pass from the region of verifiable facts to a region where hypotheses and assumptions prevail, and where scientific creed-building is the chief occupation of some very eminent men. Sir J. J. Thompson, proceeding to develop and clarify his model of atomic structure, introduced a new and revolutionary factor which, in theoretical physics, has inverted the order of things and has turned the world upside down. Starting with the known fact that an electric charge has inertia, which simulates mass. Kaufmann investigated experimentally the mass of corpuscles moving with different velocities (a condition found in the $\beta$-rays of radium), and discovered that the mass of a moving particle varies with the velocity; therefore, a part of the mass is of electrical origin. Thomson saw that he could use this discovery to improve and extend his corpuscular theory. If a part of the mass of a corpuscle is of electrical origin, why not the whole of it? Assuming the whole mass to be electrical mass he deduced from his model atom, made up of specified arrangements of positive and negative electricity, many of the properties of the real atom. By this process the corpuscle of Thomson, the electron of others, becomes, to use a well-worn metaphor, a disembodied unit of electricity. The material part has been eliminated, only the electrical part remains. With this new idea incorporated, Thomson's theory may be stated in this manner: An atom consists of a collection or system of corpuscles revolving in orbits within a sphere of positive electrification. Thus matter has been deposed from its position as a fundamental substance. It is only a mode of electrical manifestation; all the properties of matter are merely properties of electricity. The revolution is complete. Electricity has been substituted for matter, and electrodynamics for mechanics.

But what is electricity, this wonderful substance of which all matter is fabricated? Is it the ultimate substance? or is it, in turn, derived from substance still more simple? The answer to these questions is being sought in the supposed relations of electricity to the ether. Since the days of Christian Huyghens (1680) the existence of a medium for the transmission of light through space has been assumed. No properties were assigned to it except extreme thinness and the power to undulate. About 1830 Faraday, that prince of experimenters, balked at the idea of action as a distance, and refused to believe that energy could pass from one body to another without some medium to transmit it. He definitely transferred electrical and magnetic energy from matter to space, and laid the basis for the modern conception of the ether and for Maxwell's electro-magnetic theory of light.

Since the ether is an indispensible postulate in the interest of the mechanical theory and now also of the final extension of the electrical theory of matter, many leaders in science have essayed to contrive a mechanical model of the ether and to endow it with properties in virtue of which it issues forth in the form of electricity, and thence in the form of material substance. This last stage in the effort to solve the problem of the constitution of matter is well set forth in the following quotations:

Sir J. J. Thomson says: "Now one view of the constitution of matter is that the atoms of the various elements are collections of positive and negative charges held together mainly by their electric attractions, and moreover, that the negatively electrified particles in the atom (corpuscles I have termed them) are identical with the small negatively electrified particles whose properties we have been discussing. On this view of the constitution of matter, part of the mass of any body would be the mass of the ether dragged along by the Faraday tubes stretching across the atom between the positively and negatively electrified constituents. The view I wish to put before you is that it is not merely a part of the mass of a body which arises in this way, but that the *whole* mass of any body is just the mass of ether surrounding the body which is carried along by the Faraday tubes associated with the atoms of the body. In fact, that all mass is mass of the ether, all momentum, momentum of the ether, and all kinetic energy, kinetic energy of the ether. This view, it should be said, requires the density of the ether to be immensely greater than that of any known substance."

Sir Oliver Lodge says:—"Thus our hypothesis is as follows: Throughout the greater part of space we find simple unmodified ether, elastic and massive, squirming and quivering with energy, yet stationary as a whole. Here and there, however, we find specks of electrified ether, isolated yet connected together by fields of force, and in a state of violent locomotion.

"These specks are what, in the form of prodigious aggregates, we know as 'matter'; and the greater numbers of sensible phenomena, such as viscosity, heat, sound, electric conduction, absorption and emission of light, belong to these differentiated or individualized and disassociated or electrified specks, which are ether flying alone, or are revolving with orbital motion in groups. The 'matter' so constituted—built of these well separated particles, with interstices enormous in proportion to the size of the specks—must be an excessively porous or gossamer-like structure, like a cobweb, a milky way, or a comet's tail; and the inertia of matter—that is, the combined inertia of a group of electrified ether particles—must be a mere residual fraction of the mass of the main bulk of undifferentiated continuous fluid occupying the same space; of which fluid the particles are hypothetically composed, and in which they freely move."

Though we may decline to accept, even as a working hypothesis, this extreme extension of the electron theory, there are, at its foundation, certain facts that mark a distinct scientific advancement, and that may justly be recalled and emphasized.

1. The atomic structure of Electricity, first suggested by Helmholtz, has been completely verified by the processes of the new science and this new natural unit—the atom of electricity—

may now rank with the other fundamental units of nature. It should not be overlooked that in all this advancement the negative unit exhibits a rare trait of character not possessed by the positive unit. The latter—the positive unit—has never yet been isolated from masses of atomic order; it is conservative and uncommunicative; but the negative unit, when disintegration of the atom occurs, leaves the grosser portions of the wreck, and with swift motion carries or is carried by the finer products of disintegration; and only by the presence of this negative charge and by its responsiveness to electrical and magnetic influences, have investigators been able to recognize the presence of these sub-atomic masses, and to make out some of their characteristics.

2. The disintegration of atoms, long predicted, is now an assured fact. The electron, as a new unit of matter, has been accepted by the advocates of the Mechanical and the Relativity theories and has virtually been incorporated by Boltzmann into his recent revision of pure Thermodynamics. The chemist, to whom the atom has long rendered invaluable service, had already anticipated its disintegration, and though he will continue to use the atom as the unit in all chemical reactions, he has no objection to entertaining the electron as a new, sub-atomic and even ultimate unit of matter.

3. The spontaneous disintegration of matter in the field of radioactivity reveals the atom as a reservoir of energy. The measurements of Curie and Labord show that the disintegration of one gram of radium produces 300,000 times as much energy as is produced by combustion of one gram of coal. Thomson estimates that enough energy is stored in 1 gram of hydrogen to raise a million tons through a hundred yards. This enormous supply of energy found within the atom has been used to account for the sun's heat, and to greatly modify our opinion as to the age of the earth. Probably the most important problem before the physicist today is that of making this enormous energy available in the world's work.

While the theory of the electronic structure of matter has thrown much light on many perplexing problems, and while it has been the tool of the engineer in his work with electric transmissions, sources of light, and related phenomena, it must not be assumed that the problem of the ultimate nature of matter has been solved. Should we assent to all the speculations that have been presented by the brilliant leaders in this field, and should we ever come to know that matter is only a transmuted form of electricity, and that electricity is of ether origin, the boundary between the known and the great unknown would still exist — only pushed a little further away. Still unanswered would be the inevitable question, What is the ether? Whatever may be the answer to this question, one may be well assured that it is not unscientific to hold that our so-called universal principles and laws have extension and application beyond that which is seen, and that our little systems are in some way related to the Unseen Universe.

Trinity College, Durham.

PLATE IV.

94

LIVE OAKS AND "MOSS"
MICHAUX'S GARDEN

# CATCHING HAWK MOTHS ON FLOWERS AT DUSK*

By C. S. Brimley.

The moths of the family Sphingidae, otherwise known as Hawk Moths or Sphinx Moths, have always been favorites of mine, ever since as a boy in England, I reared the privet hawk moth from its larva.

In America however I had only picked up an occasional specimen till 1899, when I caught several Lined Hawk Moths (Deilephila lineata) on nasturtium flowers in the day time, and tried with very poor success to rear the Pink-spotted Hawk Moth (Phlegethontius cingulatus) from larvae of varied markings on Japanese morning glories which were growing on my porch.

Next year however the fun began. I was living in another part of town, and had an order for a dozen specimens of each species to fill, which gave me an excuse to catch all I could get. Somehow or other, I dont remember how now, I found or thought that some species were attracted to the flowers of the common jimsonweed (Datura stramonium) at dusk, and as there were a good many of these plants in my yard, I commenced to watch them when they began to bloom, and soon found that more or less hawk moths came round them. I watched the jimsonweed flowers nearly all summer at dusk, and soon found that it was hard to catch a moth on them, as one seldom stayed long enough on one flower to be caught. I then conceived the idea of gathering the flowers as soon as they opened, (they open about dusk and wither next day), and tying them in bunches on the plants or on other plants, and this worked like a charm, as a moth now had enough flowers in one place to keep him busy until I had caught or tried to catch him.

The large majority of the moths caught in this and other years belonged to two species, the Northern Tobacco Hawk Moth (Phlegethontius quinquemaculatus (celeus)), and the Southern Tobacco Hawk Moth (P. sexta (carolina)), the next

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*Read before the N. C. Academy of Science, April 28, 1911.

most common species was the Lined Hawk Moth (Deilephila lineata), while other species caught less frequently in this and other years were the Pink-spotted Hawk Moth (Phl. cingulatus), the Trumpet-vine Hawk Moth (Sphinx plebeius), the Great Ash Hawk Moth (Phl. rusticus), the Pandorus Hawk Moth (Pholus pandorus), the Tersa Hawk Moth (Theretra tersa) and the Papaw Hawk Moth (Dolba hylaeus). Not a single specimen of the Lesser Grape Hawk Moth (Ampelophaga myron) was seen around the flowers in any year, although it is one of the commonest species, and is commonly attracted to sugar, nor did the Ash Hawk Month (Ceratomia undulosa), which breeds commonly in my garden on privet and Chionanthus ever appear among my list of captures.

Returning from this digression to the year 1900, I would say that my captures consisted of six Tobacco Hawks between June 15 and 19, followed by a gap of 19 days in which none were seen, then from July 9 to 31, 37 moths were taken, all but seven of which were Northern Tobacco Hawks; in August only 20 moths were taken, 12 of them being Southern Tobacco Hawks, three Northern ditto, and the rest scattering. No moths were taken on flowers later than August 24.

Next year the two species of tobacco hawk moths simply swarmed. Between June 11 and 28, 73 hawk moths were taken, there being 36 each of the two tobacco moths and one other, then followed a gap of 23 days in which none were taken, dividing the moths into two flights as in the previous year. Note that I say flights, not broods for whilst the first flight consists wholly of moths from overwintering pupae, yet moths from overwintering pupae also enter very largely into the composition of the second flight.

The second flight began on July 22, and reached its height before the end of the month, continuing however until the middle of August, after which time none were taken till Aug. 27 when they were found again in small numbers till Sep. 6, after which there was a third gap followed by a fourth small flight from Sep. 23 to Oct. 7 on pink moonvine flowers.

During the second flight 79 Northern tobacco, 19 Southern tobacco, and 7 other hawk moths were caught between July 22 and 31; and 43 northern tobacco, 45 southern tobacco, and 4 other hawks from Aug. 1 to 15; in the third flight, Aug. 27 to Sep. 6, 11 northern tobacco, 11 southern tobacco, and 4 others; while the fourth flight, Sep. 23 to Oct. 7, gave me 7 lined hawks, two each of the two tobacco moths, and one pink-spotted hawk.

Total number caught on flowers in 1901, 308, of which 173 were the northern tobacco, 111 southern tobacco and 24 scattering.

Next year there were hardly any moths at all, the unusual abundance of the previous year having presumably caused such an increase of their parasites as to nearly wipe them out for for the time being. Curiously enough while the northern tobacco hawk moth was so common during 1900 and 1901, yet I only came across two larvae of the species, while the larva of the southern species, the common tomato worm, abounds on tomato, jimsonweed and allied plants.

After 1901, I made no notes of any importance for several years on hawk moths, although I still continued catching them to a less extent. During this time however I abandoned the unornamental jimson weeds, and adopted in their stead the well known four o'clock (Mirabilis jalapa), in which the flowers while substantially of the same character are smaller, more numerous and in bunches.

In 1909 I conceived the idea that it would be interesting to find out the proportion of sexes among the moths that visited the flowers, and took notes of all I caught in 1909 and 1910, showing that males visited the flowers much more frequently than females. Thus of the southern tobacco hawk, 42 males and 22 females were taken in 1909, and 31 males and 12 females in 1910, of the northern tobacco hawk, 15 males and 10 females in 1909, and 5 males and no females in 1910, of the lined hawk moth 11 males and 1 female in 1909, and 2 males and no females in 1910, of other species, 7 males and 1 female in 1909, 6 males and no females in 1910, making a total of 119 males and 46 females of all kinds in both years, making the proportion of the sexes about 5 males to 2 females.

On the other hand my friend George Lay, while catching moths on jimsonweed Aug. 4-25, 1910, caught 1 male and 9 females of the southern tobacco moth. My specimens however were all caught on four o'clocks.

Two other items of interest were discovered during these two years, the first being that my neighbours' cat or cats also caught hawk moths on the four o'clock flowers after I had quit for the night, the second was that the moths flew much later, up to ten o'clock in fact on bright moonlight nights, whereas on dark nights they quit as soon as it got really dark. I found this out by going after them with an old bicycle lamp in one hand and my net in the other, the first thing that my light fell on when approaching the four o'clocks usually being the cat. That cat or cats also devoured quantities of male polyphemus moths attracted by newly emerged females in my breeding cages, as many as 30 pairs of wings being found one morning. I tried hard to poison that cat last year or to disgust him, using arsenic, tartar emetic, and cyanide, but the latter he did not eat, while the two former he disgorged.

Raleigh, N. C.

# THF TURKEY BUZZARD MUST GO.*

By George W. Lay.

In Bible times we are told that dead bodies were left to the birds of the air and the beasts of the field. In other words in old times the work of these natural scavengers was relied upon to remove as quickly as possible dead bodies of all kinds. They were relied upon to do all the scavenger work, since modern scientific ideas of sanitation had not then been perfected. These primitive methods have been to a large extent continued even to the present day.

In Oriental countries dogs are still expected to do the necessary work in cleaning up from the streets, and the neighborhoods of the dwellings of man, all refuse matter they are capable of devouring. But the end of dogs as scavengers has now arrived. It was only within a short time that Constantinople sent all the dogs from its streets away to an island and gave up this primitive method of getting rid of disagreeable waste. It is generally recognized in these days that we no longer depend on dogs as public scavengers.

The time has now come when the turkey buzzard should also be dispensed with as a scavenger. He is the means of spreading disease, and on the other hand, if he has not sufficient food furnished him, he is known to become a predatory bird, and to take off chickens and young animals, such as pigs.

It is well established now that such diseases as hog cholera are carried from place to place by turkey buzzards, and even by English sparrows. The danger from small birds cannot very well be avoided, but at least they are not likely to cover a large radius, and people living in a neighborhood where careful sanitary measures are taken can guard against danger of infection from such birds as the sparrow. But the turkey buzzard flies to a great height, and may go from a hog pen where there is hog cholera and the next time he lights be at a distance of ten to forty miles. If therefore the turkey buzzard is pro-

*Read before the N. C. Academy of Science, April 28, 1911.

tected, and one must take the risk of having one of them settle on his land, there is no way of being sure that he has not brought infection from hogs suffering with hog cholera from a very long distance.

The turkey buzzard is a beautiful bird when seen at a great distance soaring in the air. He is however a hideous and obscene bird when seen close at hand. He has been protected partly for sentimental reasons on account of the beauty and wonder of his flight, and partly because in times past he was relied upon to dispose of the dead bodies of animals that were intentionally put in remote spots, in order that he might devour and destroy them. Modern sanitary ideas demand that all dead animals should be buried since there is always a danger of disease, even in thos ewho die without being suspected of it. There fore, if the careless method of disposing of animals by putting them on the surface of the earth is used, the turkey buzzard is a source of danger because in the case of a diseased animal he could carry the disease to far distant points. If on the other hand sanitary methods are used, then the turkey buzzard is deprived of the means of subsistence, and he will do damage in other ways. Many cases are already known in neighborhoods where proper sanitary methods were used with regard to the disposal of dead animals, and of other waste material, where the turkey buzzard has seized, killed and eaten chickens, young pigs, and other young animals. While perhaps public sentiment does not justify the extermination of the turkey buzzard at the present time, it seems reasonable to conclude that the protection of the turkey buzzard ought now to be ended, and that it should be allowable to kill them if they come on land whose owners are sufficiently educated in sanitary matters and the transmission of disease, to wish to prevent turkey buzzards from putting them in danger.

St. Mary's School, Raleigh.

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## PHYSICAL PROPERTIES OF AQUEOUS SOLUTIONS CONTAINING AMMONIA AND CITRIC ACID.*

BY ROBERT A. HALL AND JAMES M. BELL.

In the analysis of commercial fertilizers for the so-called "available" phosphoric acid, it is usual to employ a solution of "exactly neutral" ammonium citrate,[1] having a specific gravity of 1.09 at 20°. After extraction of the fertilizer with water, the residue is treated with the citrate solution and the phosphoric acid which remains undissolved is termed insoluble, or non-available; that which the water dissolves is the water-soluble; and that dissolved in the citrate solution is the reverted or citrate-soluble. The sum of the water-soluble and the citrate-soluble phosphoric acid constitutes the available. Upon the results of these analyses depend the valuation of the fertilizer material, and, if the guarantee accompanying the fertilizer claims a higher percentage of phosphoric acid than is shown in the analysis by the state chemist, the manufacturer is liable to a fine.

In the preparation of the "exactly neutral" ammonium citrate solution, however, great difficulty is encountered, due to the lack of sensitiveness of every color indicator. This lack of sensitiveness in the color indicator is general in the neutralization of a weak base, such as ammonium hydroxide, by a weak acid, such as citric acid.

The Association of Official Agricultural Chemists prescribes[1] the use of a saturated alcoholic solution of corallin as indicator in testing for the neutrality of the citrate solution; also an "optional

*Reprinted from The Journal of the American Chemical Society, Vol. XXXIII, No. 5. May, 1911.

[1]Bureau of Chemistry, *Bull.* 107 (revised), 1.

method" wherein the citrate is precipitated by an alcoholic solution of calcium chloride, and the filtrate tested for acidity or alkalinity with cochineal as indicator. This method is employed apparently with the object of avoiding the difficulty experienced in determining the end point in the former method. That both methods are unreliable and unsatisfactory is evidenced by the fact that at almost every meeting of chemists engaged in fertilizer analyses there is animated discussion of, and general protest against both the "official method" and the "optional method" on account of the difficulty in getting a sharp end point with corallin, or any other color indicator.

In the absence of any satisfactory color indicator of the end point in the neutralization of a weak acid by a weak base, several physical properties of mixtures of ammonia and citric acid have been investigated with a view of applying these to the determination of the end point. The use of conductivity as an indicator of neutrality has been demonstrated by Küster and Grüters[2] in the titration of weak acids by strong bases, the conductivity being measured after each addition of the base to the solution. By plotting the quantity of alkali against the conductivity, a decided break was found in the curve just at the neutral point. The solution consisted of a mixture of the acid and salt in varying proportions up to the neutral point, after which it was composed of the alkali and salt. The method of conductance has also been employed to determine the acidity of colored liquids,[3] such as wines, where the color of the liquid would mask the color change of the indicator.

Another physical measurement has been used by Ostwald, viz., density, as an indicator of the neutral point, a sharp break in the composition-density curve being found at this point of neutrality.

The present paper contains the results of measurements of conductivity and of density of a series of solutions containing constant amounts of citric acid and varying amounts of ammonia in a fixed volume of solution. The conductivity measurements were made

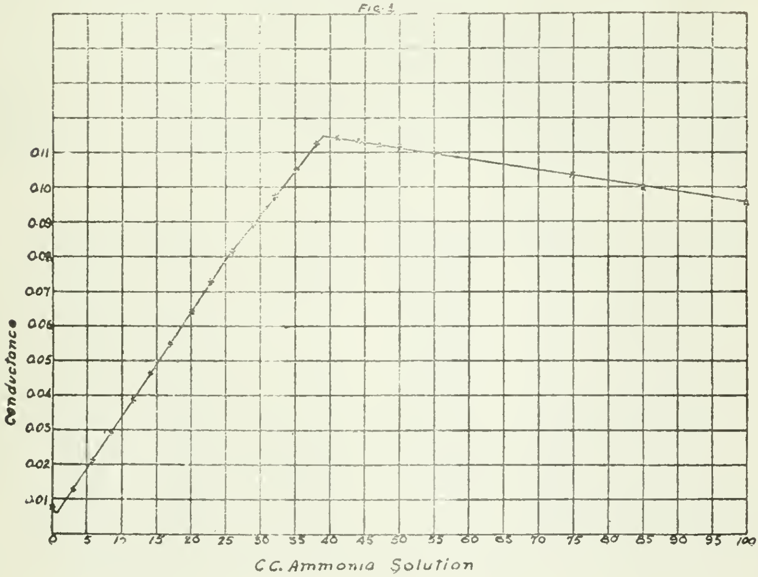
1. Bur. of Chem., *Bull.* 107 (revised), 1.

2. *Z. anorg. Chem.*, 35, 454 (1903).

3. Kuster and Gurters, *Loc. cit.*; Geibel, *Z. anorg. Chem.*, 42, 231 (1905).

with the usual Wheatstone apparatus, the conductivity cell used being of the H. C. Jones type, designed for concentrated solutions. In making up the solutions standardized (D. & R.) pipets, burets, and flasks were used, and also, as a check, the flask and contents were weighed after each addition This was deemed advizable on account of the very concentrated solutions used and on account of the volatility of the ammonia. In order to minimize the loss of ammonia by evaporation, the stock solution was siphoned from a bottle protected with a capillary opening. The flow of liquid into the buret was controlled by a glass stopcock, and the top of the buret was closed except for a capillary opening. The outflow from the buret was made through a small tube, drawn to a capillary opening, of sufficient length to pass nearly to the bottom of the flask in which the solutions were mixed. This capillary tube was coated on the outside with a high-melting paraffin to prevent the solution in the flask clinging to the tube when the ammonia solution was led into the body of the citric acid solution. The escape of ammonia was thus minimized or prevented entirely, no ammo-

Fig. 1



nia being noticeable by odor or by a change of color of moist neutral litmus paper.

Each solution in the first series of conductivity measurements had a total volume of 200 cc. This contained 100 cc. of a solution of pure citric acid (Kahlbaum's). 370 grams per liter, thus approximating the citrate content of the solution employed in fertilizer analysis.[1] To these solutions were added in the way described above varying amounts of the ammonia solution, whose exact strength was determined both by titration against standardized acid and also by density determinations. The 200 cc. measuring flask was then cooled and filled up to the mark with distilled water. After thorough mixing, the solutions were transferred to glass-stoppered bottles and placed in the thermostat which was electrically heated and controlled. The temperature was maintained at 25°, within 0.01°. This temperature was chosen rather than 20°. at which the fertilizer chemist makes this specific gravity determination, because of the inconveniences of running a thermostat at a temperature below that frequently existing in this neighborhood.

In another series of measurements the above solutions were diluted one-half, 100 cc. to 200 cc., and the conductivities ascertained.

In Table I are given the results of the conductivity measurements of the concentrated solutions, made as described above. The quantity of citric acid solution used was always 100 cc., weighing 113.00 ± 0.02 grams. In figure I the conductivities are plotted against the cc. of ammonia.

TABLE 1.

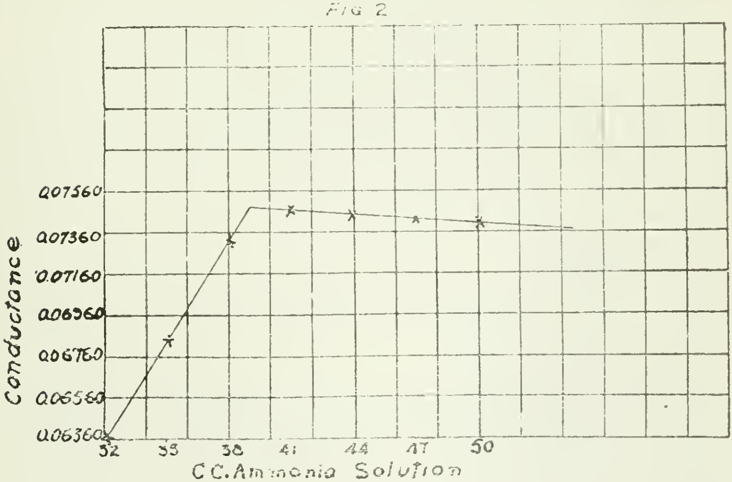
| Solution no. | Ammonia solution cc. | Conductivity | Solution no. | Ammonia solution cc. | Conductivity |
|---|---|---|---|---|---|
| 1 | 0.00 | 0.007791 | 12 | 32.00 | 0.09731 |
| 2 | 3.00 | 0.01292 | 13 | 35.00 | 0.1052 |
| 3 | 5.75 | 0.02113 | 14 | 38.00 | 0.1124 |
| 4 | 8.60 | 0.02943 | 15 | 41.00 | 0.1145 |
| 5 | 11.55 | 0.03901 | 16 | 44.00 | 0.1132 |
| 6 | 14.31 | 0.04629 | 17 | 47.00 | 0.1124 |
| 7 | 17.15 | 0.05500 | 18 | 50.00 | 0.1116 |
| 8 | 20.00 | 0.06401 | 19 | 75.00 | 0.1032 |
| 9 | 23 00 | 0.07271 | 20 | 85.00 | 0.09990 |
| 10 | 26.00 | 0.08187 | 21 | 100.00 | 0.09523 |
| 11 | 29.00 | 0.08984 | | | |

1. *Loc cit.*

It will be seen in Figure I that there is a sharp break in the curve at the point representing 39 cc. of the ammonia solution. The strength of the ammonia solution used in these experiments was determined by density measurements and also by titration against hydrochloric acid of known strength. This acid was compared with a solution of caustic soda, which was standardized by comparison with a normal solution of oxalic acid made by weighing the exact amount of oxalic acid. The titrations with oxalic acid were made with phenolphthalein, and those with ammonia with methyl orange as indicator. By this method the ammonia was found to be 13.51 normal. Therefore, the 39 cc. of ammonia solution contains 0.5268 mols. $NH_3$. Of citric acid in 100 co. of acid solution there are 37 grams, equal to 0.156 mols. Now, 0.5268/0.176=2.993; that is, the neutral solution, as determined by this method is at triammonium citrate.[1] This suggests the applicability of the conductivity method for determining the neutral point of ammonium citrate solution.

Some of the above solutions were diluted one-half; that is, 100 cc. of the solution were diluted to 200 cc., and the conductivities

Fig 2




ascertained. In Table II the measurements are given, and in Fig.

1. Van Itallie, *Z. anorg. Chem.*, 60, 358 (1908).

2 the conductivities are plotted against the cc of ammonia solution as before. The break in the conductivity curve of the diluted solutions agrees with that found for the more concentrated ones, showing that a dilution of one-half has no influence on the neutral point as found by this method.

TABLE II.

| Solution no. | Ammonia solution cc. | Conductivity. | Solution no. | Ammonia solution cc. | Conductivity |
|---|---|---|---|---|---|
| 12 | 32.00 | 0.06360 | 16 | 44.00 | 0.07440 |
| 13 | 35.00 | 0.06841 | 17 | 47.00 | 0.07418 |
| 14 | 38.00 | 0.07330 | 18 | 50,00 | 0.07402 |
| 15 | 41.00 | 0.07471 | | | |

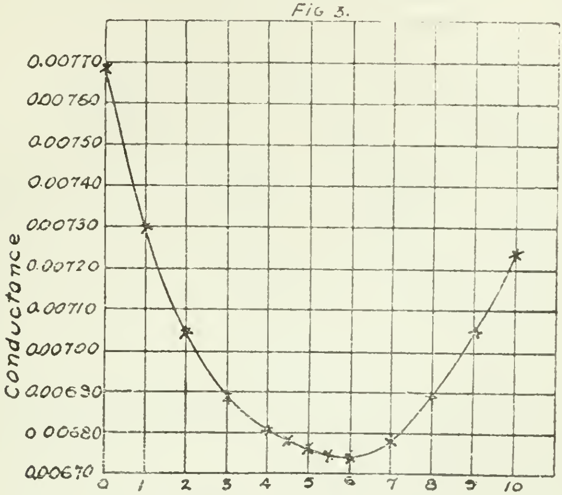
It will be noticed further in the curve of Fig. I that the first point of the curve does not fall in the smooth curve with the other points up to the neutral point. To investigate the failure of this point to fall on the regular curve there was made a further series of measurements in which the quantities of ammonia solution added differed by smaller increments (0.5 cc.). This showed that the curve has a minumum. In a further series of measurements having a still smaller increment of ammonia solution (0.1 or 0.2 cc.) the region of this minimum was more carefully investigated. In this series the original ammonia solution was diluted ten times and so 0.1 or 0.2 cc. of the original solution correspond to 1 or 2 cc. of the diluted solution. In Table III the measurements are given and in Fig. 3 the conductivities are plotted against the number of cc. of the diluted ammonia solution.

TABLE III.

| Solution no. | Ammonia cc. | Conductivity | Solution no. | Ammonia cc. | Conductivity. |
|---|---|---|---|---|---|
| 1 | 0.00 | 0.00768 | 8 | 5.50 | 0.00674 |
| 2 | 1.00 | 0.00730 | 9 | 6.00 | 0.00674 |
| 3 | 2.00 | 0.00704 | 10 | 7.00 | 0.00678 |
| 4 | 3.00 | 0.00689 | 11 | 8.00 | 0.00689 |
| 5 | 4.00 | 0.00681 | 12 | 9.00 | 0.00705 |
| 6 | 4.50 | 0.00678 | 13 | 10.00 | 0.00724 |
| 7 | 5.00 | 0.00676 | | | |

With a strong acid at great dilution successive additions of ammonia (or any other base) would lower the conductivity, due to the displacement of the exceedingly mobil hydrogen ion by the slower moving ammonium ion. With a weak acid, however, two

Fig 3.




opposing factors enter, the hydrogen ion being being replaced, as before, by the ammonium ion, and also the salt having a far higher degree of dissociation than the acid. The second factor is probably the predominant one and slight additions of ammonia would increase the conductivity. Should the citric acid contain a minute amount of a strong acid, the strong acid would be neutralized first, and thus give a minimum conductance. Whether this minimum be due to impurities, or whether other weak bases and weak acids exhibit the same phenomenon is still under investigation in this laboratory.

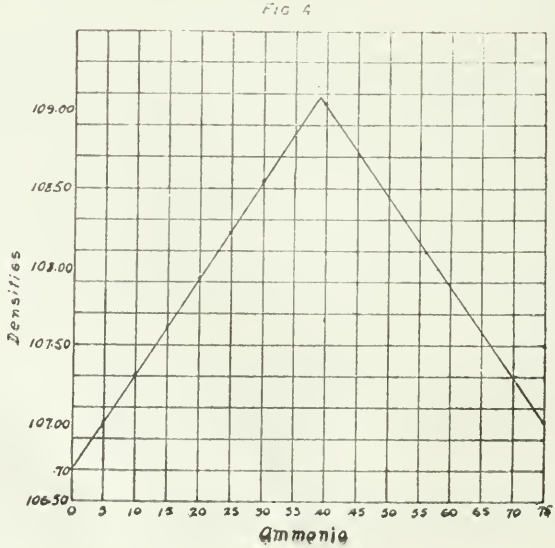
Another method of determining the neutral point of ammonium citrate solution was suggested by the fact that chloroform dissolves free ammonia[1] but does not dissolve citric acid or ammonium citrate and therefore may be used as an agency for removing $NH_3$

1. Hantzsch and Sebaldt, Z. *physik. Chem.*, 30, 266 (1899); Abbott and Bray, *J. Am. Chem. Soc.*, 31, 729 (1909).

from its salts, if ammonia be present in excess. A series of nine solutions, containing 35, 36, 37........ 43 cc. of ammonia solution, respectively, was prepared, and each solution shaken with chloroform. The chloroform extracts from the solutions containing 35 to 39 cc. of ammonia solution showed no free ammonia on titration with dilute sulfuric acid, methyl orange being used as indicator. The extracts from solutions containing 40 to 43 cc.of ammonia solution contained increasing amounts of free ammonia. Thus the presence of free ammonia in the citrate solution may be detected by shaking out with chloroform and testing the chloroform layer for free ammonia. This offers another method for establishing the end point when citric acid is being neutralized by ammonia.

A series of measurements of the densities of solutions containing citric acid and ammonia offer further confirmation of the position of the neutral point. In preparing these solutions 50 cc. of citric acid solution were placed in a 100 cc. measuring flask and ammonia was added. Water was then added to the mark and the flask and contents weighed and the density computed in the usual way. In Table IV the data thus obtained are given, and in Fig. 4, the

FIG. 4



number of cc. of ammonia solution is plotted against the densities. It is seen that the neutral solution has the maximum density and that this solution is the same as that indicated by the break in the curve obtained by the conductivity method.

Table IV.

| Solution no. | Ammonia solution cc. | Density | Solution no. | Ammonia solution cc. | Density |
|---|---|---|---|---|---|
| 1........... | 0 | 1.0670 | 7........... | 30 | 1.0853 |
| 2........... | 5 | 1.0700 | 8........... | 35 | 1.0883 |
| 3........... | 10 | 1.0731 | 9........... | 40 | 1.0903 |
| 4........... | 15 | 1.0762 | 10........... | 45 | 1.0874 |
| 5........... | 20 | 1.0792 | 11........... | 50 | 1.0864 |
| 6........... | 25 | 1.0822 | 12........... | 75 | 1.0702 |

## Summary

In this paper it has been shown that the neutral point for a weak acid and a weak base, such as citric acid and ammonia may be accurately determined by conductivity measurements; that the presence of an excess of ammonia in the ammonium citrate solution may be ascertained by shaking out with an immiscible solvent, as chloroform, which dissolves a part of the excess of the base but neither the free acid nor the salt; and that the neutral point of the ammonium citrate solution may also be established by density determinations.

Chapel Hill, N. C.

# PREPARATION OF NEUTRAL AMMONIUM CITRATE SOLUTIONS BY THE CONDUCTIVITY METHOD*

BY ROBERT A. HALL.

In their investigations of the properties of aqueous solutions containing ammonia and citric acid,[1] Hall and Bell found that the neutral point of the solution could be detected by conductivity measurements, and this suggested the application of the conductivity method as a possible means of preparing the neutral ammonium citrate solution required in fertilizer analysis for the determination of the citrate-insoluble phosphoric acid in a fertilizer. In order to ascertain the possibility of readily and easily preparing neutral ammonium citrate by the application of the conductivity method the following experiments were made by the author of this article.

A citric acid solution was prepared of such a citrate content that when neutralized by ammonia its specific gravity would be greater than 1.09 at 20°; that is, 370 grams of pure citric acid[2] were dissolved in ammonium hydroxyde of 0.90 sp. gr. and water, until the solution was near the point of neutrality, yet leaving the solution acid to litmus paper. Care was taken that the volume was not over one liter. The solution was allowed to stand over night to cool. It was again tested with litmus paper to see that it was distinctly acid. Also, small portions, one to two cc., were withdrawn with pipettes and roughly titrated with a diluted ammonia solution in order to ascertain the approximate amounts of ammonia solution necessary to make the citrate solution distinctly alkaline to litmus. The diluted ammonia solution used was prepared by taking the concentrated ammonium hydroxide, sp. gr. 0.90, and diluting exactly exactly ten times, that is, 100 cc. were diluted to one liter. A sufficient amount of this solution was prepared to have enough for the making of the solution for the conduc-

*Reprinted from the Journal of Industrial and Engineering Chemistry, Vol. 3 No. 8. August, 1911.

[1] *J. Am. Chem. Soc.*, **33**, 711.

[2] Method of Analysis; *Bull.*, **107**, Bureau of Chemistry, p. 1.

tivity measurements and also for addition to the larger bulk of the acid ammonium citrate solution, of the calculated amount of ammonia solution as shown by the conductivity measurements, for complete neutrality. 100-cc. lots of the nearly neutralized ammonium citrate solution were withdrawn with pipettes and put in 200 cc. volumetric flasks. Definite amounts of the diluted ammonia solution were measured into these different flasks. Water was then added to the mark, the solution thoroughly mixed, and the flasks placed in an electrically controlled thermostat. The temperature of this thermostat was maintained at 25°, plus or minus 0.01°. When these solutions had come to the temperature of the bath their conductivities were determoned with a Wheatstone bridge in the usual way. The conductivity cell used was the H. C. Jones type for concentrated solutions. The conductances were plotted against the cc. of the ammonia solution used. It was easy to read from the curve thus obtained the number of cc. of the ammonia solution needed to neutralize exactly 100 cc. of the acid ammonium citrate solution used. This amount of the diluted ammonia solution was then measured into a 200 cc. flask containing 100 cc. of the citrate solution and water added to the mark. After thorough mixing, the flask was placed in the bath and allowed to come to bath temperature. Its conductivity was then ascertained. Its conductance showed it to have the amount of ammonia necessary for exact neutralization. The solution, when tested with corallin, methyl orange, methyl red, and neutral litmus paper (Squibb's), gave no evidence of the presence of either acid or base. Also, the solution was shaken out with chloroform, the chloroform separated from the citrate solution and shaken with water and the water tested for ammonia.[1] No ammonia was found. Hence it was concluded that a neutral ammonium citrate solution had been prepared with accuracy and certainty.

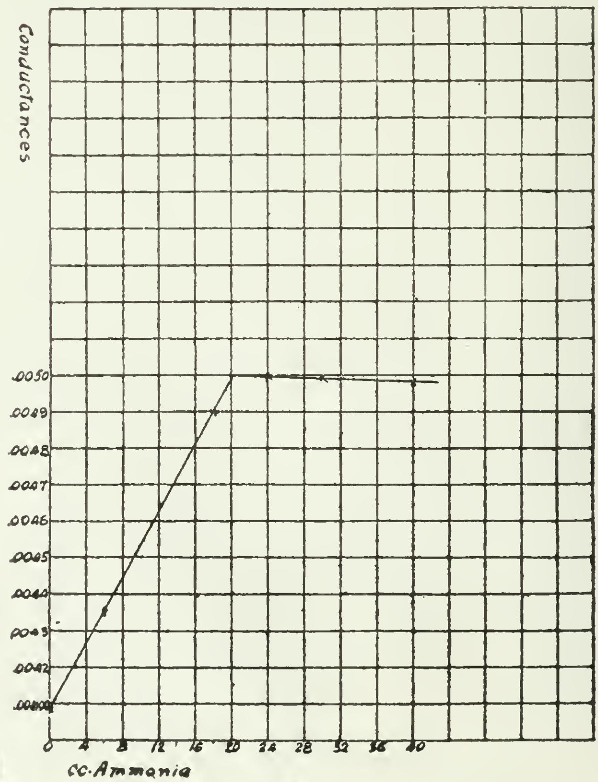
Specific gravity determinations were also made of the solution used in these conductivity determinations and the densities plotted against the cc. of ammonia. The curve showed that the neutral solution as prepared by the conductivity curve had the highest specific gravity.[1]

[1]Hall and Bell, *Loc. cit.*

In Table I is given the data obtained in these measurements, and in Fig. 1 the conductances are plotted against the cc. of ammonia solution used.

TABLE I.

| Solution No. | Cc. ammonia. | Conductivity. |
|---|---|---|
| 1 | 0.00 | 0.004085 |
| 2 | 6.00 | 0.004353 |
| 3 | 18.00 | 0.004900 |
| 4 | 24.00 | 0.004997 |
| 5 | 30.00 | 0.004991 |
| 6 | 40.00 | 0.004980 |
| 7 | 20.30 | 0.004999 |



The neutral solution as prepared above had a specific gravity greater than 1.09 at 20°. It was therefore an easy matter to dilute with distilled water and in the usual way bring to the required density.

In order to investigate the possibility of the use of the conductivity method of preparing neutral ammonium citrate solution by the chemist who has not the use of an electrically controlled thermostat, or a thermostat regulated by any other method wherein a constant temperature is secured, a series of experiments were made in which the use of the regulated thermostat was dispensed with; that is, the electrical control was cut off and the temperature of the bath allowed to vary with that of the room. However, a time of experimentation was chosen so that there was a minimum of variation of room temperature. In brief, the experiments were conducted under such conditions as can be had in any laboratory where a room fairly well protected from the usual weather variations and from the presence of those entering and leaving the room during the time of the experiment can be had. In the place of the thermostat a tub of water could have been used for the bath.

The solutions were prepared as above, placed in the bath and allowed to come to the temperature of the bath. Erlenmeyer flasks of suitable volume and of such sized mouth as to admit of easy entrance of the electrodes of the cell were placed in the bath, so that when the solutions were being changed in the cells the electrodes could be placed in these flasks and be kept at the temperature of the bath, thus preventing the slight lowering of temperature due to the evaporation of the water on the electrodes. The conductivity measurements were made as rapidly as possible (each was run in less than one and one-half hours), the cells and electrodes being carefully washed each time with the new solution. This rinsing was repeated three times for each change of solutions. During the short intervals of waiting necessary for the cell and its solution to come to bath temperature again after the handling the conductances were computed and the curve plotted, so that as soon as possible after the last point in the curve was located and the curve completed. It was found further that by plotting the bridge readings against the cc. of ammonia solution used that the same results were obtained as by plotting the conductances against the cc. of ammonia solution. In this way it was possible to make the series of six measurements in a very short time, usually less than one and one-half hours being required, and thus minimize the probability of any great change of room temperature. From the curve was read the amount of ammonia solution needed to be added to 100 cc. of the acid ammonium citrate in order exactly to neutralize it. This amount of ammonia was run into a 200 cc. flask containing the solution previously measured out, water added to the mark and the solution thoroughly mixed. The flask was then placed in the bath and brought to the temperature of the bath. The conductivity measurement was then made. It was found that the bridge reading obtained corresponded exactly to the bridge reading on the curve for neutral ammonium citrate solution. The same amount of ammonia was then run into another 100 cc. lot of the ammonium citrate solution and this solution made up a specific gravity of 1.09 at 20°. When these solutions were tested with indicators and chloroform, as above, they gave no evidence of containing either acid or free ammonia in access.

The bath was now brought again to a tempergture of 25° and maintained their by the electrical control while the conductivity measurements were repeated. These gave a curve showing the neutral point to be the same as that found at room temperature.

In Table II are given the data of the measurements made at room temperature. In Fig. 2 the bridge readings are plotted against the cc. of ammonia solution used:

TABLE II.

| Solution No. | Cc. ammonia. | Bridge-reading. |
|---|---|---|
| 1 | 0.00 | 49.40 |
| 2 | 10.00 | 52.01 |
| 3 | 18.00 | 54.09 |
| 4 | 24.00 | 54.80 |
| 5 | 30.00 | 54.75 |
| 6 | 36.00 | 54.70 |
| 7 | 20.80 | 54.84 |

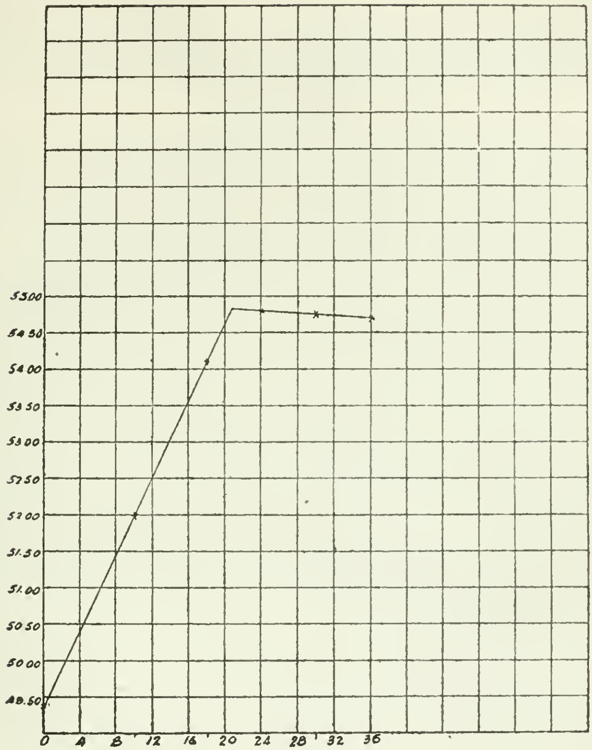



Fig. 1.

An effort was made to ascertain the possibility of preparing a neutral citrate solution by adding an excess of ammonia and afterwards removing this excess by extractions with chloroform.[1] Although repeated extractions were made, there was always free ammonia remaining in the citrate solution. This was to be expected as the ammonia is so much more soluble in water than in the chloroform. Moreover, had it been possible to extract all the free ammonia from the solution the chloroform that would have remained in solution in the citrate solution would have precluded the use of this method for the preparation of neutral ammonium

[1]Hall and Bell, *Loc. cit.*

citrate for the fertilizer analysis, as the chloroform would be decomposed, forming free hydrochloric acid, which would interfere with the determination of the citrate insoluble phosphoric acid.

## CONCLUSION

It has been shown that the conductivity method of preparing neutral solutions is applicable to the preparation of exactly neutral ammonium citrate solutions of such a density that they can after neutralization, be diluted with distilled water and brought to a density of 1.09 at 20°. This method can be applied under conditions such as can be easily obtained in any laboratory and therefore seems worthy of adoption as an "Official Method" of preparing the exactly neutral ammonium solution required in fertilizer analysis for the determination of the citrate insoluble phosphoric acid content of the fertilizer. For the regulated thermostat there may be substituted a tub of water. However, a thermostat of constant temperature is preferable, for then there is no necessity of the measurements being carried out so quickly as when the measurements are made in a bath at room temperature.

CHAPEL HILL, N, C.

# THE DISTRIBUTION OF AMMONIA BETWEEN WATER AND CHLOROFORM.*

BY JAMES M. BELL AND ALEXANDER L. FEILD.

The distribution of ammonia between water and chloroform has been studied by several investigators. The results have been employed to determine the concentration of free ammonia in an aqueous solution, which contains also some compound of ammonia, such as the blue cuprammonia compounds and the phosphates of ammonium. Until recently the distribution was determined only for dilute solutions, where the concentration of ammonia in the water layer was not greater than normal.

Hantzsch and Sebaldt[1] found that the ratio of the concentrations of ammonia in water and chloroform is 25.1 at 25°, the mean of five determinations in which the concentration in the water layer varies from 0.00275 to 0.04425 normal. At 2° this ratio is 38:53. Dawson and McCrae[2] give the following values for the distribution ratio: 26.3 at 20°, 24.9 at 25°, and 23.2 at 30°, the highest concentration in the water layer being 14.14 grams $NH_3$ per liter. In a later paper Dawson and McCrae[3] repeated their determinations at 20°, the extreme concentrations of ammonia in the water layer being being 5.160 and 17.168 grams $NH_3$ per liter. Between these limits the distribution ratio is not quite independent of the ammonia concentration. The ratio varies from 26.36 for the most dilute solution to 25.32 for the most concentrated.

The following quotation is from a later paper by Dawson:[4] "In reference to the distribution of ammonia between pure water and chloroform, it has already been shown that the concentration ratio $H_{H_2O}/C_{CHCl_3}$ decreases with increasing ammonia concentra-

*Reprinted from The Journal of The American Chemical Society, Vol. XXXIII. No. 6. June, 1911.

[1] *Z. physik. Chem.*, **30**, 258 (1899).

[2] *J. Chem. Soc.*, **77**, 1239 (1900).

[3] *J. Chem. Soc.*, **79**, 493 (1901).

[4] *J. Chem. Soc.*, **89**, 1668 (1906)

tion, but the relationship between these two factors could not be determined with a desirable degree of accuracy in the case of dilute solutions containing less than 0.5 mol. of ammonia per liter of aqueous solution." Consequently new determinations were made at 19.5° by an improved method. Representing $k$ (the distribution rato) as a function of $c'$ (the concentration in the chloroform layer) the points so obtained lie approximately on the straight line corresponding to the equation

$$k = 26.16 - 34.14c'.$$

Abbott and Bray[1] have also found the distribution ratio with the object of determining the degree of hydrolysis of several phosphates of ammonium in aqueous solution. At 18° the ratio is 27.45, where the aqueous layer has a concentration between 0.02 and 0.05 normal.

In more concentrated ammonia solution , Dawson[2] has found that at 18° the distribution ratio decreases from 26.46 at 0.928 normal to 21.70 at 4.333 normal.

The present paper contaius the results of an investigation of this distribution at 25° and over a much wider range of concentration. Chloroform was added to aqueous solutions of ammonia of varying strength. The bottles were placed in an electrically heated and controlled thermostat at 25° and were frequently shaken. When equilibrium had been reached, a known volume of each layer was titrated against standard acid. The following table contains the concentration of ammonia in each layer expressed in gram molecules per liter and also the distribution ratio between the two layers.

It will be seen from the table that the distribution varies from 22 in dilute solution to about 10 in concentrated solution. The limit to which the distribution tends at very great dilution appears to be about 24.

TABLE I.

| Normality $NH_3$ in water layer. $c$ | Normality $NH_3$ in $CHCl_3$ layer. $c'$ | Distribution ratio. $k$ |
|---|---|---|
| 1.02 | 0.045 | 22.7 |

[1] *J. Am. Chem. Soc.*, **31**, 729 (1909).

[2] *Z. physik. Chem.*, **69**, 110 (1909).

| | | |
|---|---|---|
| 2.08 | 0.095 | 21.9 |
| 3.13 | 0.146 | 21.4 |
| 3.98 | 0.205 | 19.4 |
| 5.24 | 0.283 | 18.5 |
| 6.25 | 0.365 | 17.1 |
| 7.29 | 0.457 | 15.9 |
| 8.34 | 0.549 | 15.2 |
| 9.35 | 0.710 | 13.2 |
| 10.23 | 0.864 | 11.8 |
| 11.24 | 1.045 | 11.0 |
| 12.23 | 1.227 | 10.0 |

The following table contains the limiting values of the distribution ratio for very dilute solutions as found at different temperatures by the various workers in this field.

Table II.

| Temp. | Dist. Ratio. | Observer. |
|---|---|---|
| 2° | 38.5 | Hantzsch and Sebaldt. |
| 18 | 27.45 | Abbott and Bray. |
| 18 | 27.5 approx. | Dawson. |
| 20 | 26.5 | Dawson and McCrae, I. |
| 20 | 25.3 | Dawson and McCrae, II. |
| 25 | 25.1 | Hantzsch and Sebaldt. |
| 25 | 24.9 | Dawson and McCrae, I. |
| 25 | 24. approx. | Bell and Feild. |
| 30 | 23.2 | Dawson and McCrae. I. |

The accompanying table (II) shows clearly that the distribution ratio falls as the temperature rises.

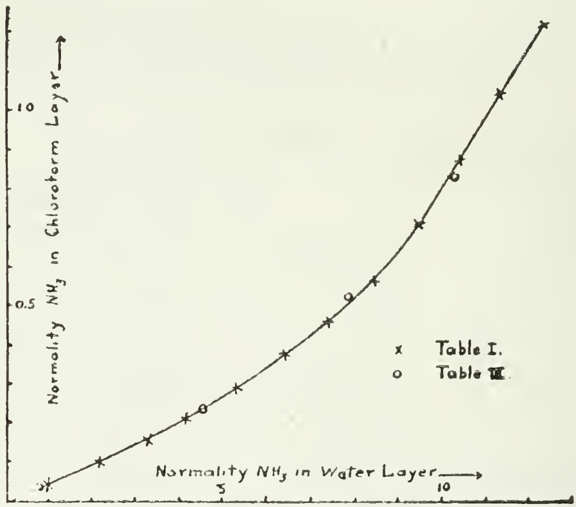
The points obtained by plotting the values of C and K in Table I lie on a curve which deviates rather far from a straight line, so that the formula given by Dawson holds only for the more dilute solutions, and is of value in giving the limiting direction of the curve. This result is confirmed by the later results of Dawson where more concentrated solutions have been used.

The effect of other compounds on the distribution ratio has been investigated by Hantzsch and Sebaldt[1] and by Dawson and McCrae.[2] As ammonia is a weak base it is but slightly ionized

[1]Z. *physik. Chem.*, **30**, 258, (1899).

[2]*J. Chem. Soc.*, **79**, 493 (1901).

even at great dilutions, and consequently the addition of an ammonium salt would increase the number of undissociated molecules very slightly, while the percentage decrease of ionization would be greatly diminished. If unionized ammonia is the substance distributed, then the presence of ammonium chloride should affect the distribution very slightly and then only on account of the "salting out" effect. If, on the other hand, the ionized portion were distributed, the presence of the highly ionized salt would affect the distribution very greatly. In very dilute




solutions Hantzsch and Sebaldt have found that ammonium chloride has almost no effect. Dawson and McCrae have, however, shown that the effect is measurable, the distribution ratio at 20° decreasing by 0.88 for each mol. of salt per liter of solution. The nitrate and sulfate also lower the distribution ratio, while the bromide increases it. The following table (III) gives the results of experiments on the distribution of ammonia between chloroform and a solution of ammonium chloride containing about 3 mols. per liter. At each concentration of ammonia the distribution ratio is very close to that found in the absence of ammonium chloride.

TABLE III.

| Normality $NH_3$ in water layer ($NH_4Cl$—3N) | Normality $NH_3$ in $CHCl_3$ layer calc. | Normality $NH_3$ in $CHCl_3$ layer obs. |
|---|---|---|
| 0.84 | 0.037 | 0.037 |
| 4.32 | 0.226 | 0.228 |
| 7.72 | 0.494 | 0.512 |
| 10.16 | 0.837 | 0.820 |

In this paper it has been shown that at 25° the distribution ratio for ammonia between water and chloroform varies with the concentration, from about 24 in dilute solution to about 10 in concentrated solution. The presence of ammonium chloride affects the distribution very slightly.

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# SOME PLUTONIC ROCKS OF CHAPEL HILL

BY WILLIAM H. FRY

The Chapel Hill area is situated in the northern central part of the state in the "Carolina Metamorphic Slate and Volcanic Belt." The area here considered is bounded on the south by igneous slates of unknown age generally spoken of as the Purefoy's Mill series; on the southeast, east, and northeast by Triassic sandstones; and on the north and west by very basic crystalline plutonics and acid volcanics of comparatively recent age, probably triassic, as bombs of the material are found embedded in the sandstone to the east. The rocks composing the area are mainly granites, the exceptions being small dikes of a diabasic nature. Watson, Laney, and Merrill[1], describe the field appearance and locations of the plutonics of the area as foliows:

"Boulders and ledge outcrops of granite are exposed along Bolans creek where crosssed by the Durham road, one mile northeast of Chapel Hill, near the contact of the crytalline rocks with the Triassic sandstones. The rock indicates much variation in texture from a very fine grained even granular granite of a decided pink color. Reddish pink feldspars, quartz and a small quantity of biotite are apparent to the unaided eye. The rock is entirely massive and is intersected by several sets of joints. No attempt has been made to quarry the stone and its marked variable texture would make it undesirable as a general building stone.

"The outcrop on the Clayton place on the north side of Brocker's creek, one and a half miles north of Chapel Hill, shows more or less variation in texture and color, though the rock is usually dark gray and of a very fine texture. No statement can be made of the working qualities of the stone.

"Four miles north of Chapel Hill and 150 yards east of the railroad is an exposure on the Brocker place, of pinkish gray granite with porphyritic tendency, containing large laths of pink

[1]Bulletin 2, N. C. Geol. Survey, 1906.

feldspar. It lacks uniformity in both color and texture and for this reason would not prove a very desirable stone for general building purposes."

The only previous petrographic work done on the area consists of two papers published by Mr. H. N. Eaton; one a description of micropegmatite in a binary granite[1], the other a few petrographic descriptions of some of the granites of the area[2].

In the introduction to the latter paper he speaks of the area as follows:

"The village of Chapel Hill, North Carolina, is located upon a gently rounded knob of granite rocks................Northward the granite becomes rapidly more basic, reaching a quartz-mica-diorite, or grano-diorite. Rocks resembling true diorites macroscopically are adjacent on the north. Aplite dikes exist everywhere, and a suite of specimens can be easily collected showing a gradation from this binary type to rocks containing biotite and hornblend. The range in color varies from fine grained, white, acid rocks, to those which are dark, medium, and coarse grained." He then gives descriptions of a few specimens and their sections.

A large number of samples have been collected by the present writer representing the area more thoroughly than did the specimens collected by Mr. Eaton. Thin sections were made from representative types of these samples. Descriptions of these thin sections and the specimens from which they were taken are given below.

I.—This rock occurs under the railroad bridge about one and a fourth miles north of the station, near the old iron mine. In hand specimen it is rather fine grained; rather dark in color, and weathers to a brownish dirty-looking soil belonging to the Iredell series. It is mottled with greenish hornblende and light feldspar.

The thin section contains magnetite, feldspar, hornblende, and quartz. The magnetite is abundantly present in comparatively small scattered granules. The feldspar is very much decomposed. The main mass of it is probably orthoclase, judging from its crys-

[1]Jour. Elisha Mitchell Scientific Society, Vol. 24, No. 3, Nov. 1908.

[2]Jour. Elisha Mitchell Scientific Society, Vol. 25, No. 3, Nov. 1909.

talline outlines. Other weathered feldspars are present, most of them probably one or more of the plagioclases. One plagioclase crystal was fresh enough for determination as labradorite. The hornblende is green in color, and is segregated into clusters mixed with magnetite, and alone. Quartz is abundantly scattered through the whole section. The rock was determined as hornblende granite.

II.—In handspecimen the rock is very finely crystallized. The color is a sort of white tinged with brown. The fracture is conchoidal althougn the rock is not so fine grained as to be cryptocrystalline. Altogether the rock has a very pronounced quartzitic appearance. It occurs about half a mile northeast of Piney Prospect in Strowd' field at the contact between the crystalline rock and the Triassic sandstone.

The thin section contains hornblende, magnetite, quartz, orthoclase, and tourmaline. The hornblende occurs sparingly scattered through the section. The magnetite is present in occasional grains. Quartz is the predominating mineral, and is intermixed with a considerably less amount of orthoclase. The tourmaline is present in small scattered grains. It doubtless owes its origin to the action of magnetic gases near the periphery of the intrusion. The rock was determined as a hornblende granite.

III.—Macroscopicolly the rock is fine grained, light with a tinge of pink in color, and very closely jointed, breaking into rhombohedra-like forms. It occurs near the Raleigh road about one fourth of a mile out from the cemetery.

The thin section contains quartz, plagioclase, hornblende, and magnetite. The quartz is abundantly present in comparatively large granules. The plagioclase feldspar is sparingly scattered through the section in very small granules. The orthoclase is slightly weathered, and is present in large masses. The hornblende is present only in a very slight amount. The magnetite is present in medium sized and scattered granules. The rock was determined as hornblende granite, almost a binary type of granite.

IV.—This rock is very fine grained, almost cryptocrystalline. It is slightly darker in color than usual and has a greenish appearance. It occurs on the Hillsboro road just north of Bolin's creek.

The thin section contains apatite, hornblende, quartz, plagioclase, and orthoclase. Apatite was located in only one place, and occurred in the form of an acicular crystal. The hornblende is scattered through the section. In one case it is segregated into a large nodule. Laths of plagioclase feldspar are abundant; while only a slightly smaller quantity of orthoclase is present. The quartz occurs mainly as the filling of a vein which traverses the section. Outside of the vein quartz, while still present, does not constitute the main mass of the rock. Along one plane of the section a s'ight normal faulting has taken place. The rock was determined as hornblende granite.

V.—This rock is of a light flesh-colored pink. The grains are medium sized. The rock is splotched with a greenish mineral. It occurs to the northwest of the hosiery mill about one half of a mile.

The section contains quartz, plagioclase, feldspar, hornblende, magnetite, and orthoclase. The quartz is present in large, irregular, and apparently stressed crystals. Some of them are filled with minute cavities and inclusions of other minerals. The plagioclase is oligoclase. Much slightly decomposed hornblende is present, and is usually segregated into particular localities. The magnetite is present only in very slight amounts. The orthoclase is not predominant. The rock was determined as hornblende granite.

VI.—In handspecimen this rock is medium grained, light pink in color, and breaks with a conchoidal fracture. It occurs on the old Durham road near its junction with the new road on the south side of Bolin's creek.

The thin section contains quartz, hornblende, and oligoclase. The quartz is present in predominating quantities. The orthoclase is abundant and is very much kaolinized. The hornblende occurs in a seam running completely through the section, with a little quartz intermixed with it. Outside the seam the hornblende is present only in very meager amounts. The oligoclase occurs as a few scattered crystals. The rock was determined as hornblende granite.

VII.—This rock is very coarsely crystalline. It is dark green in color mottled with white and pink feldspars. It occurs south of the Raleigh road near the cemetery. The section contains hornblende, magnetite, quartz, labradorite, orthoclase, and biotite. The hornblende is present in large amounts as small scattered crystals. The magnetite is present in very small quantities. The quartz occurs filling the interstices between the other minerals. Labradorite is present in small quantities. Orthoclase is the prevailing feldspar, and occurs in large crystals, almost phenocrysts. Biotite is present in very small amounts. It is brown in color. The rock was determined as hornblende-biotite granite.

VIII.—This rock is medium grained in texture and light gray in color. Macroscopically a flake or two of biotite were noticed. but the mineral was in negligable quantities. None was located in this section. The rock occurs on the campus of the University of North Carolina near the athletic field.

The section contains orthoclase, hornblende, chlorite, quartz, and magnetite. The quartz is the predominant mineral and occurs in large, well defined crystals. The orthoclase occurs as crystals which are much kaolinized and are almost phenocrysts in certain cases. The hornblende is in small scattered crystals occupying a very inferior area of the section. It is greenish and brownish in color. The chlorite is green and probably represents a decomposition product. The magnetite occurs very sparingly in small scattered masses. The rock was determined as hornblende granite.

IX.—This rock is very fine grained macroscopically. The color is very light gray. The rock occurs on the Pittsboro road about a mile out from the Chapel Hill public school.

The thin section contains quartz, hornblende, feldspars, and magnetite. The quartz occurs as phenocrysts scattered through a groundmass composed of the other minerals present, and as small crystals composing a part of the groundmass. The crystals are studded with gas bubbles. A rather large veinlet is filled with quartz. The hornblende occurs in rough, irregular patches and stringers. The crystals individually are very small. A small vein running nearly across the section has hornblende for its vein material. The feldspar is probably a mixture of orthoclase and one or more of the plagioclases. The crystals are very small, but show good crystalline outlines between crossed nicols. The shapes are rather elongate The magnetite occurs very sparsely as small granules. The rock was determined as hornblende granite.

X.—This is a very fine grained and light colored rock. It occurs on the Chatham road near its junction with Cameron Avenue.

The section contaihs quartz, hornblende, and feldspar. The quartz occurs as large phenocrysts and occupies the larger portion of the section. In several instances good hexagonal outlines were observed. A large sized veinlet filled with quartz extends nearly across the section with somewhat of a crank-shaped course. The outline between the vein and the wall is very clearly drawn. In some cases horses of the groundmass of the rock occur in the vein. The vein was evidently formed by some mechanical disturbance and filled by silica-bearing solutions. The hornblende occurs in stringers and small scattered crystals. The stringers in one locality are all sheared and drawn out in parallel directions, indicating some mechanical disturbance. The feldspar is very fine grained and is probably orthoclase. It forms the main groundmass material of the section. The rock was determined as hornblende granite.

XI.—This is a medium grained and quartzitic-appearing rock. The color is a very light pink. Macrascopically the rock appears to be almost a binary type. It occurs to the north of Chapel Hill near the "Colorado Canon."

The thin section contains quartz, orthoclase, magnetite, hornblende, chlorite, plagioclase, and a negligible quantity of biotite. The quartz occupies the major portion of the section. It occurs in large, well developed, and apparently stressed masses. The orthoclase occurs in masses somewhat larger than those of the quartz. It is slightly kaolinized. Pieces showing good crystalline outlines are rare. It is also apparently stressed. The magnetite occurs in small scattered masses occupying a very inferior portion of the section. The hornblende occurs scattered promiscuously through the rock, seldom in large masses. Chlorite was observed in one instance as a small, ill-defined mass. It is probably a decomposition product. The plagioclase is probably labradorite. It was observed in only one locality. The crystal was very small and irregular. The rock was determined as hornblende granite.

XII.—This rock is very coarse grained and very dark in color, mottled with green. It occurs to the north of Chapel Hill on the the hill north of the Oxford road.

The thin section contains quartz, hornblende, orthoclase and magnetite. The quartz occurs in well defined crystals often showing hexagonal outlines The crystals show a tendency to segregation in small masses. The hornblende occurs in clearly marked crystalline forms with well marked cleavage. It is greenish and brownish in color. The orthoclase is slightly kaolinized and shows no crystalline form. It occurs in large masses intermixed with the hornblende. The magnetitite occurs in small scattered granules. The rock was determined as hornblende granite.

XIII.—This rock is rather coarsely crystalline and of a deep pink color. The fracture is sub-conchoidal. It occurs in Battle's Park south of the Dissecting Hall.

The section contains quartz, orthoclase, plagioclase, hornblende, magnetite, and biotite. The quartz occurs in large irregularly shaped masses seldom showing any distinct crystalline outlines. The plagioclase is labradorite. It occurs sparingly scattered through the section in well defined crystalline forms, and shows perfect twinning. The hornblende occurs in small segregated masses and fairly well defined crystals of medium size scattered promiscuously through the rock. In some instances the cleavage can be observed, but not without difficulty. The magnetite occurs more abundantly than usual as medium sized but scattered granules. It occupies only an inferior portion of the rock section. Biotite occurs sparingly in small scattered flakes. The cleavage can usually be made out. It is brownish in color. The rock was determined as hornblende-biotite granite.

XIV.—This is a very coarsely crytalline rock. The color is light gray mottled with black. It occurs in the alley near the residence of Mr. H. H. Patterson on Cameron Avenue. The rock is very much decomposed.

The section contains quartz, orthoclase, hornblende, and magnetite. The quartz occupies the major portion of the section, and occurs in masses which are almost phenocrysts. The crystals are intergrown with each other in a remarkably irregular manner. The orthoclase occurs in large masses, and in some of these the cleavage can be very well observed in spite of the decomposed condition of the mineral. In one case a perfect crystal of orthoclase was found imbedded in an irregular mass of the same mineral. The hornblende shows a marked tendency to segregation into large bunches. It is green in color, and in the individual crystals, the cleavage can be made out fairly well. The magnetite, as usual, occurs in small sized, scattered granules usually, but not always, associated with the hornblende. The rock was determined as hornblende granite.

XV.—In handspecimen this rock is very coarsely granular. In color it is light gray splotched with black. It occurs on Franklin street near the residence of Prof. E. V. Howell. The sample was collected from an excavation made for sewerage. When exposed the rock is very much decomposed.

The thin section contains quartz, orthoclase, hornblende, and magnetite. The quartz occurs in large grained, irregular masses occupying probably half of the section. The orthoclase is very much kaolinized, but shows good crystalline outlines. It occurs in large crystals. The hornblende occurs in abundance. It is greenish in color and shows practically absolutely perfect cleavage. The magnetite occurs in irregularly scattered granules. The rock was determined as hornblende granite.

Out of the nine granites described by Mr. Eaton in the papers already referred to only one was a hornblende granite, two were binary granites, one a muscovite granite, one a biotite-hornblende granite, and four were biotite granites. These cover pretty thoroughly the types of acid plutonics found in this area; but the papers give a wrong conception of the relative proportions of each type. In the present paper, out of fifteen sections described, thirteen were hornblende granites, while the other two were hornblende-biotite granites. It is thought, both from field evidence and from the present work, that this latter proportion comes nearer being representative of the acidic area than does the former. The biotite granites undoubtedly exist here, but seldom without a great deal of hornblende intermixed. The muscovite and binary granites must be considered as rare exceptions.

# MINERALS OF THE CHAPEL HILL REGION

BY WILLIAM H. FRY.

The following minerals are known to occur in the Chapel Hill area: gold, pyrrhotite, pyrite, quartz, flint, hematite, magnetite, some manganese minerals, limonite, orthoclase, microcline, oligoclase, andesine, labradorite, augite, hornblende, zircon, epidote, tourmaline, muscovite, biotite, chlorite, prochlorite, serpentine, talc, kaolinite, titanite, apatite. Many more are doubtless present, but so far they have not been brought to light.

*Gold* occurs in a quartz vein about two and one half miles north of the village of Chapel Hill. The vein runs in a north to northeast and southwest direction. The material has been assayed and was found not to be economically valuable.

*Pyrrhotite* has been determined by the writer from specimens collected in the dump heaps of the old Chapel Hill iron mine. It is of very rare occurrence in this locality.

*Pyrite* occurs rarely in material from the iron mine. In some cases it carries a trace of copper. As a magmatic segregation it is found rather abundantly in connection with the basic plutonics of the area. As an accessory mineral it occurs in practically all the igneous rocks of the neighborhood.

*Quartz*, besides its occurrence as a rock constituent, is found in numerous veins. These range in width from a fraction of an inch to sometimes several feet. Here the mineral is undoubtedly an aqueous precipitate. Beautifully formed crystals are occasionally found in geodes of the country rock. The flint of the area is of doubtful nature. It seems to be a very acid volcanic rock rather than the true mineral.

*Hematite* is found abundantly at the Chapel Hill iron mine where it was formerly worked. The ore[1] has been considered as the filling of an ordinary fissure vein. Analyses of some of the ore from the mine are as follows[2]:

*Magnetite* occurs admixed with the other iron ores of the Chapel

[1]Nitze, Bull. 1, N. C. G. S.

[2]Roberts, J. C., this Journal, 1883-'84, pp. 26-27.

Hill mine, as an accessory rock constituent, and float ore. Writing of this float ore John L. Borden[1] has the following:

"This magnetite is found on the farm of—Cheek, about three miles south of Chapel Hill. Pieces ranging up to ten or fifteen pounds in weight are found scattered over the field. One of these was analyzed with the following result:

| | |
|---|---|
| Magnetic iron oxide | 96.03 |
| Silica | 3.02 |
| Water | .52 |
| Sulphur | .19 |
| Phosphorus | trace |
| | 99.76" |

*Manganese minerals*[2] occur admixed with limonite in Strowd's field. "The formation is similar to the formation of bog iron ore. There is only a small quantity of the ore, scattered on the surface." There is another occurrence on the Cheek farm somewhat similar to the above. Other small occurrences have been located. The manganese minerals composing the deposits have not been separately determined. They probably consist of the oxides and hydrates.

*Limonite* occurs abundantly. The ore usually is found in the shape of bog deposits.

*Orthoclase, microcline, oligoclase, andesine, hornblende, zircon, epidote, muscovite, biotite, chlorite, titanite, and apatite*[3] have been reported as occurring in the granites of the area. In addition to these the writer has found labradorite, augite, and tourmaline in thin sections of the country rocks. The tourmaline occurs in the granites near their contact with the Triassic sandstones.

*Prochlorite*[4] has been found about one-fourth of a mile from Orange Church north-east of Chapel Hill. It occurs admixed with decomposed muscovite.

*Serpentine*[5] has been reported from somewhere near Chapel Hill.

[1]This Journal, 1883-'84: p. 87.

[2]Pratt, J. H., Unpublished Notes.

[3]Eaton, H. N., This Journal, Vol. 25, No. 3, Nov., 1909.

[4]Pratt, J. H., loc. cit.

[5]Genth, F. A., "Minerals of North Carolina."

The writer has not been able to verify this occurrence.

*Talc* occurs rather commonly in connection with the more basic rocks of the area.

*Kaolinite*, almost pure, was found by the writer about one fourth of a mile to the rear of Mr. Patterson's residence on Cameron Avenue. The deposit covers about five or six square yards.

# FORMULAS FOR INVESTMENT CALCULATIONS

BY THOMAS F. HICKERSON

This is an attempt to present clearly and logically all the formulas needed for various interest and sinking fund computations that may come within the field of the engineer. Many of these formulas, in a less general form than given in this paper, have been found here and there in algebras, civil engineering text books and journals, while others have never been seen in print.

## SIMPLE INTEREST.

Let P=Principal in dollars.

r=Rate of interest. [Interest on $1 for one year.]

n=Total time in years.

I=Interest on the principal at the end of n years.

A=Amount at end of n years.

Then, $I=Prn$ ............................................(1)

Solving for P, r, and n we have

$P=I/rn$; $r=I/Pn$; $n=I/Pr$. ........................ (2)

Also, $A=P+I=P+Prn=P(1+rn)$ ..................(3)

Solving for P, r, n and I, we have

$$P=\frac{A}{(1+rn)};\quad r=\frac{(A-P)}{Pn};\quad n=\frac{(A-P)}{Pr};\quad I=\frac{Arn}{(1+rn)}$$

........................................(4)

## COMPOUND INTEREST.

Interest is compounded when it is added to the principal and becomes a part of the principal at specified intervals.

Let P=Principal in dollars.

r=Rate of interest (Interest on $1 for one year.)

n=Total time in years.

t=Time in years between two successive compoundings; thus, if the interest is to be compounded quarterly, $t=1/4$

A=Amount at end of n years.

It is evident that the total number of periods [compoundings] equals $\frac{n}{t}$ and the rate per period equals rt.

Amount at end of 1st period $=P+Prt=P(1+rt)$

" " " " 2nd " $=P(1+rt)+P(1+rt)\times rt=P(1+rt)^2$

" " " " 3rd " $=P(1+rt)^2+P(1+rt)^2\times rt=P(1+rt)^3$

Hence, the amount at the end of the last or $(n/t)^{th}$ period, in accordance with the above observed law, $=P(1+rt)^{n/t}$.

Hence, we have $A=P(1+rt)^{n/t}$........................(5)

If interest is compounded annually $(t=1)$ $\therefore A=P(1+r)^n$

" " " " semi-annually $(t=\frac{1}{2})$ $\therefore A=P(1+\frac{r}{2})^{2n}$

" " " " quarterly $(t=\frac{1}{4})$ $\therefore A=P(1+\frac{r}{4})^{4n}$

etc.

Solving for P and n respectively, we have

$$P=\frac{A}{(1+rt)^{n/t}}\ ;\quad n=\frac{t\times(\log A-\log P)}{\log(1+rt)}\ \ldots\ldots\ (6)$$

No simple formulas can be derived for r and t.

If the interest is not compounded annually, we may use tables made for the case when it is compounded annually, as follows: Compute the number of periods (conversions) and the rate per period and use the tables just as though the periods were years and the rate per period were rate per year.

### SINKING FUNDS.

A sinking fund is a sum of money which must be set aside at the end or beginning of each successive interval of time (usually at the end of each year) and placed at interest in order to amount to a specified sum in n years.

To Find the Amount of a Sinking Fund.

a) Simple interest basis.

Let S = value of the sinking fund in dollars.

n = number of years.

r = rate of interest.

k = length of time (in years) between payments.

A = amount of sinking fund at end of n years.

Total number of payments $= \frac{n}{k}$

First, suppose payments to be made at the *end* of each period of k years.

$A_1 =$ amount of 1st S in (n—k) years $= S + Sr\,(n-k)$
$A_2 =$ " " 2nd S in (n—2k) " $= S + Sr\,(n-2k)$
$A_3 =$ " " 3rd S in (n—3k) " $= S + Sr\,(n-3k)$
......... ................................ ..................... ........
$A_{n/k} =$ " " $(\frac{n}{k})$th S in $(n - \frac{n}{k} \times k)$ years $= S + O$

$\therefore A = A_1 + A_2 + A_3 + \ldots A_{n/k} = \frac{n}{k} S + Sr \times \frac{n}{2k}(n-k) \ldots (7)$

If $k = 1$, $A = n\,S + Sr \times \frac{n}{2}(n-1) \ldots\ldots (8)$

Next, suppose the payments to be made at the *beginning* of each period of k years; then it follows similarly that

$A = \frac{n\,S}{k} + Sr \times \frac{n}{2k}(n+k) \ldots\ldots\ldots (9)$

If $k = 1$, $A = n\,S + Sr \times \frac{n}{2}(n+1) \ldots\ldots\ldots (10)$

The difference between the amounts as given by formulas (7) and (9) equals S r n, which is the interest on S dollars at r per cent for n years.

Example.

$100 set aside at the end of every six months and placed at simple interest at 6 per cent for 10 years will amount to, using formula (7), $2 \times 10 \times 100 + .06 \times 10 \times 9.5 = \$2570$.

If this amount is set aside at the *beginning* of every period of six months, we have, using formula (9):

$A = 2000 + 100 \times .06 \times 10 \times 10.5 = \$2630$.

b) Compound interest basis.

Let S, n, r, k, and A represent the same notation as used above. In addition, let t = time in years between successive compoundings of interest.

First, suppose the payments to be made at the *end* of each period of k years.

Amount of 1st S in (n—k) years $= S\,(1+rt)^{\frac{n-k}{t}}$
" " 2nd " " (n—2k) " $= S\,(1+rt)^{\frac{n-2k}{t}}$
" " 3rd " " (n—3k) " $= S\,(1+rt)^{\frac{n-3k}{t}}$
.................................................. .....

" " $\left(\frac{n}{k}\right)$th S in $\left(n-\frac{n}{k}\times k\right)$ years $=S$

$$A=S(1+rt)^{\frac{n-k}{t}}+S(1+rt)^{\frac{n-2k}{t}}+S(1+rt)^{\frac{n-3k}{t}}+\ldots+S$$

Hence, summing up the geometric series, we have

$$A=\frac{S[(1+rt)^{n}/t-1]}{(1+rt)^{k}/t-1} \qquad \ldots\ldots\ldots\ldots (11)$$

or $$S=\frac{A[(1+rt)^{k}/t-1]}{(1+rt)^{n}/t-1} \qquad \ldots\ldots\ldots\ldots (12)$$

Formula (12) gives the necessary sinking fund to accumulate an amount A in n years, etc.

If $k=1$, $t=1$, then

$$A=\frac{S[(1+r)^{n}-1]}{r} \qquad \ldots\ldots\ldots\ldots (13)$$

$$S=\frac{Ar}{(1+r)^{n}-1} \qquad \ldots\ldots\ldots\ldots (14)$$

Next, suppose the payments to be made at the *beginning* of each period, then

$$A=S[(1+rt)^{n}/t+(1+rt)^{\frac{n-k}{t}}+\ldots\ldots+(1+rt)^{k}/t]=$$

$$\frac{S[(1+rt)^{\frac{n+k}{t}}-(1+rt)^{k}/t]}{(1+rt)^{k}/t-1} \qquad \ldots\ldots\ldots\ldots (15)$$

If $k=1$, $t=1$, then

$$A=\frac{S[(1+r)^{n+1}-(1+r)]}{r} \qquad \ldots\ldots\ldots\ldots (16)$$

The difference between the amounts as given by formulas (11) and (15) equals $S[(1+rt)^{n}/t-1]$, which is the amount of S dollars at r per cent. compound interest for n years.

Example.

$100 set aside at the end of every six months and placed on interest, compounded semi-annually at 6 per cent. for 10 years will amount to, using formula (11), with $r=.06$, $k=\frac{1}{2}$, $t=\frac{1}{2}$, $n=10$, $S=100$;

$$A=\frac{100[(1.03)^{20}-1]}{.03}=\$2687.03$$

If this amount is set aside at the *beginning* of every period we have, using formula (15),

$$A=\frac{100[(1.03)^{21}-(1.03)]}{.03}=\$2767.64$$

## ANNUITY.

An annuity is a fixed sum of money payable at definite intervals of time (not necessarily every year). Evidently an unpaid annuity, with interest, will amount to the same sum as a sinking fund set aside at the same intervals. Hence, the formulas already derived for the amount of a sinking fund are also applicable for finding the amount of an annuity.

## PRESENT VALUE OF FUTURE PAYMENTS.

The present value, P, of A dollars payable n years hence is equal to that sum P which when' placed at interest for n years will amount to A dollars.

Hence, $P=\frac{A}{(1+rt)^{n/t}}$ [See formula (6)] .........(17)

If $t=1$, $P=\frac{A}{(1+r)^n}$ .....................(18)

Also, on simple interest basis, we have

$P=\frac{A}{(1+nr)}$ [See formula (4)]..... ...............(19)

The present value, P, of an annuity of S dollars payable at the *end* of every interval of k years for a period of n years with interest compounded at the end of each interval of t years is the *same* as that sum P which, if placed at compound interest, would amount to A dollars, where A equals the amount of the annuity in n years.

$A=\frac{S[(1+rt)^{n/t}-1]}{(1+rt)^{k/t}-1}$ [See formula (11)]

$A=P(1+rt)^{n/t}$ [See formula (5)]

Hence, $P(1+rt)^{n/t}=\frac{S[(1+rt)^{n/t}-1]}{(1+rt)^{k/t}-1}$

$$\therefore\ P = \frac{S\left[1 - \dfrac{1}{(1+rt)^{n}/t}\right]}{(1+rt)^{k}/t - 1} \quad \ldots\ldots\ldots\ldots\ldots(20)$$

If k=1, t=1,

$$P = \frac{S\left[1 - \dfrac{1}{(1+r)^{n}}\right]}{r} \quad \ldots\ldots\ldots(21)$$

The present value of a perpetual annuity ($n = \infty$) equals

$$\frac{S}{(1+rt)^{k}/t - 1} = \frac{S}{r}\ (\text{if } k = t = 1) \quad \ldots\ldots\ldots\ldots(22)$$

Equating formulas (3) and (7) it follows that, on a simple interest basis,

$$P = \frac{\dfrac{nS}{k}\left[1 + \dfrac{r}{2}(n-k)\right]}{(1+nr)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(23)$$

$$\text{If } k=1,\ P = \frac{nS\left[1 + \dfrac{r}{2}(n-1)\right]}{(1+nr)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(24)$$

The present value of an annuity of S dollars payable at the beginning of every period of k years, etc., is

$$P = S\left[\frac{(1+rt)^{k}/t - (1+rt)^{\frac{k-n}{t}}}{(1+rt)^{k}/t - 1}\right] \quad \ldots\ldots\ldots\ldots(25)$$

$$\text{If } k = 1,\ t = 1, \text{ then } P = \frac{S\left[(1+r) - \dfrac{1}{(1+r)^{n-1}}\right]}{r} \quad ..(26)$$

If the annuity is perpetual ($n = \infty$),

$$P = \frac{[S(1+rt)^{k/t} - 0]}{(1+rt)^{k/t}} = \frac{S(1+r)}{r}\ (\text{if } k=t=1)\ldots(27)$$

Equating formulas (3) and (9) it follows that, on a simple interest basis,

$$P = \frac{\frac{nS}{k}\left[1+\frac{r}{2}(n+k)\right]}{(1+nr)} \qquad (28)$$

$$\text{If } k=1,\ P=nS\left[\frac{\left[1+\frac{r}{2}(n+1)\right]}{(1+nr)}\right] \qquad (29)$$

The difference between the present values as given by formulas (25) and (20) equals

$$S\left[1-\frac{1}{(1+rt)^{n/t}}\right]$$

Example.

Find the present value of an annuity of $1 for 20 years with interest at 4 per cent.

Payments at end of each year:

P (Compound interest basis) = $13.59 (Formula 21)

P (Simple " " = $15.33 (Formula 24)

Payments at beginning of each year:

P (Compound interest basis) = $14.13 (Formula 26)

P (Simple " " ) = $15.78 (Formula 29)

To find the present value of an annuity which is to begin (a) years hence and continue at the *end* of each interval of time k (in years) for b years, interest being compounded every t years.

The present value of such an annuity, were it to begin k years hence and continue for (a+b) years, equals

$$\frac{S\left[1-\frac{1}{(1+rt)^{\frac{a+b}{t}}}\right]}{(1+rt)^{k/t}-1} \qquad \text{(See formula 20)}$$

The present value of such an annuity, were it to begin k years hence and continue for (a) years, equals

$$\frac{S\left[1-\frac{1}{(1+rt)^{a/t}}\right]}{(1+rt)^{k/t}-1} \qquad \text{(See formula 20)}$$

The present value required is evidently the difference between the above expressions.

$$\text{Hence, } P = \frac{S\left[\frac{1}{(1+rt)^{a/t}} - \frac{1}{(1+rt)^{\frac{a+b}{t}}}\right]}{(1+rt)^{k/t}-1} \quad \ldots\ldots(30)$$

$$\text{If } b=\infty,\ P = \frac{S\left[\frac{1}{(1+rt)^{a/t}}\right]}{(1+rt)^{k/t}-1} = \frac{S\left[\frac{1}{(1+r)^{a}}\right]}{r}$$

$$(\text{if } k=t=1) \ldots\ldots\ldots\ldots(31)$$

If the annuity is to begin (a) years hence and continue at the *beginning* of every interval of k years, etc., then it follows similarly that

$$P = \frac{S\left[(1+rt)^{\frac{k-a}{t}} - (1+rt)^{\frac{k-a-b}{t}}\right]}{(1+rt)^{k/t}-1} \quad \ldots\ldots\ldots(32)$$

$$\text{If } b=\infty,\ P = \frac{S\left[(1+rt)^{\frac{k-a}{t}}\right]}{(1+rt)^{k/t}-1} = \frac{S\left[(1+r)^{1-a}\right]}{r}$$

$$(\text{if } k=t=1) \ldots\ldots\ldots(33)$$

To find the future value $P^1$, the value m years hence, of an annuity of S dollars payable at the *end* of of every k years for n years, interest compounded every t years.

$P^1$ is evidently equal to the amount of the annuity of S dollars for m years plus the present value of the annuity of S dollars for (n—m) years.

Hence, using formulas (11) and (20), we have

$$P^1 = S\left[\frac{(1+rt)^{m/t}-1}{(1+rt)^{k/t}-1}\right] + \frac{S\left[1-\frac{1}{(1+rt)^{\frac{n-m}{t}}}\right]}{(1+rt)^{k/t}-1}$$

$$= S\,\frac{\left[(1+rt)^{\frac{2n-m}{t}}-1\right]}{\left[(1+rt)^{k/t}-1\right]\ (1+rt)^{n/t}} \quad \ldots\ldots\ldots(34)$$

If k=1, t=1

$$P^1 = S\left[\frac{(1+r)^{2n-m} - 1}{r\,(1+r)^n}\right] \text{........ ............}(35)$$

If S is payable at the *beginning* of every period of k years, etc., then it follows similarly that

$$P^1 = S\left[\frac{(1+rt)^{\frac{m+k}{t}} + (1+rt)^{\frac{k-n-m}{t}}}{(1+rt)^{k}/t-1}\right]\text{...}(36)$$

If k=1, t=1:

$$P = \frac{S\left[(1+r)^{m+1} - (1+r)^{1-n-m}\right]}{r}\text{...........}(37)$$

BONDS.

Bonds are written or printed obligations to pay a certain amount of money at a specified future time, together with the interest as at becomes due.

Let P=price of a bond in dollars.

n=time (in years) the bond has to run.

r=rate of interest on par value of bond.

V=face of the bond (V=P, if bought at par value).

s=current rate of interest, compounded every t years.

x=desired rate of interest on the investment.

$P\,(1+tx)^n/t$=value of the purchase money at the end of n years. [See formula (5)].

kVr=interest on the bond, received at the *end* of each interval of time k.

The total amount received from the bond in n years, if each installment of interest is immediately put at compound interest at 100s per cent=

$$kVr(1+ts)^{\frac{n-k}{t}} + kVr(1+ts)^{\frac{n-2k}{t}} \;..\; + kVr + V =$$

$$V + kVr \times \frac{(1+ts)^n/t-1}{(1+ts)^k/t-1}$$

Now, let $P(1+tx)^{n/t}=V+kVr\times\frac{(1+ts)^{n/t}-1}{(1+ts)^{k/t}-1}$

Hence, $$(1+tx)=\left[\frac{V}{P}+\frac{kVr\times[(1+ts)^{n/t}-1]}{P\,[(1+ts)^{k/t}-1]}\right]^{t/n} \quad ..(38)$$

Example.

What interest will a purchaser receive on his investment if he buys at 120 a 6 per cent bond, with interest payable semi-annually, that has 25 years to run, money being worth 5 per cent.

$V=100$, $P=120$, $n=25$, $s=.05$, $t=1/2$, $k=1/2$.

$$\left(1+\frac{x}{2}\right)=\left[\frac{100}{200}+\frac{3\,[(1.025)^{50}-1]}{120\times(.025)}\right]^{1/50}=1.024 \text{ (Formula 38)}$$

$$\therefore x=.048=4.80\%.$$

FUTURE PROVISION FOR A BOND ISSUE.

Let it be desired to find what constant payment Q (including interest) must be made at the end of each period of k years in order to extinguish a principal A in n years, it being understood that each payment shall apply first to the interest due at the date of payment, and the remainder, after this is satisfied, be deducted from the principal before the interest for the next period is calculated.

It is evident that Q must be equivalent to the interest per period plus the sinking fund per period necessary to amount to the principal in n years. Hence, we have, using formula (12):

$$Q=\frac{A\,[(1+rt)^{k/t}-1]}{(1+rt)^{n/t}-1}+kAr \quad \ldots\ldots\ldots\ldots (39)$$

$$\text{If } k=1,\ t=1;\ Q=\frac{Ar}{(1+r)^{n}-1}+Ar \quad \ldots\ldots\ldots\ldots (40)$$

If the payments are to be made at the *beginning* of each period of k years, then we have, using formula (15):

$$Q=\frac{A\left[(1+rt)^{k/t}-1\right]}{(1+rt)^{\frac{n+k}{t}}-(1+rt)^{k/t}}+\frac{kAr}{(1+rt)^{k/t}} \quad \ldots\ldots\ldots\ldots (41)$$

If k=1, t=1; $Q = \frac{Ar}{(1+r)^{n+1} - (1+r)} + \frac{Ar}{1+r}$ ........ (42)

To find the aggregate payment and the partial payments, if Y dollars and also the interest on the reduced principal are to be paid at the end of every period of k years, so that the whole debt will be cancelled in n years.

Let us assume $\frac{n}{k}$ = whole number.

Evidently, $Y = \frac{A}{(n/k)} = \frac{kA}{n}$

Total amount paid at end of first period of k years $= kAr + \frac{kA}{n}$

Amount at end 2nd period$= \left(\frac{A - kA}{n}\right) kr + \frac{kA}{n}$

Amount at end 3rd period$= \left(A - \frac{2kA}{n}\right) kr + \frac{kA}{n}$

Amount at end of $\left(\frac{n}{k}\right)$th period $= \left(A - \left(\frac{n}{k} - 1\right) \left(\frac{kA}{kn}\right)\right) \times kr + \frac{A}{n}$

$$\text{Total} = kr \left[\frac{nA}{k} - [0 + \frac{kA}{n} + \frac{2kA}{n} + \ldots \ldots \left(\frac{n}{k} - 1\right) \frac{kA}{n}]\right] + A$$

$$= Ar\left(\frac{n+k}{2}\right) + A \ldots\ldots\ldots\ldots (43)$$

Difference between any two successive payments,

$$= Ar \times \frac{k^2}{n}$$

Example:—$100,000 in bonds at 4 per cent for 20 years are issued. In order to meet this by the end of 20 years, $5,000 and whatever interest may be due, are paid at the end of each year.

What will be the aggregate amount paid and how do the payments vary?

$A=100,000$, $n=20$, $k=1$, $r=.04$, $Y=5000$.

$$\text{Total} = 4000 \times \left(\frac{21}{2}\right) + 100,000 = \$142,000.$$

Difference between payments $= 4000 \times \frac{1}{20} = \$200$; that is, the annual payment would start at \$9000 and decrease by \$200 each succeeding year.

### RELATIVE ECONOMY.

There are several methods of comparing the costs of articles of structures in order to decide which will be the most economical in the long run. All of these methods of comparison lead to the same relative result, as will be seen later. The following elements must be considered: (1) first cost; (2) life of article or structure; (3) cost of replacement or renewal; (4) rate of interest; (5) cost of maintenance; (6) salvage or scrap value of the article at the close of its period of usefulness.

### CAPITALIZATION.

The capitalized cost of an article is that sum which is suffi cien to pay the first cost and provide for future cost of maintenance and renewals forever.

Let $C$ = first cost of article.

$C^1$ = cost of renewal.

$M$ = cost of maintenance during each interval of k years.

$n$ = life of article in years.

$D$ = scrap value of article at end of n years.

$r$ = rate of interest, compounded every t years.

$X$ = required capitalized cost.

$M^1$ = the amount at compound interest necessary to produce at the end of every k years the cost of maintenance.

$R$ = the amount which, when put at compound interest, will provide a sum at the expiration of the useful life of the article sufficient to renew it and also to leave a sum equal to the original amount (less the scrap value) for further future provision.

Then $X = C + M^1 + R$

Now, $M^1 = \dfrac{M}{(1+rt)^{k/t} - 1}$ (See formula (22); the present worth of a perpetual annuity.)

If R is placed at compound interest, as stated above, we must have

$$R\,(1+rt)^{n/t} = (C^1 - D) + R$$

$$\text{Whence } R = \frac{(C^1 - D)}{(1+rt)^{n/t} - 1}$$

Substituting these values of $M^1$ and R, we have the general formula for the capitalized sum:

$$X = C + \frac{M}{(1+rt)^{k/t} - 1} + \frac{(C^1 - D)}{(1+rt)^{n/t} - 1} \quad \ldots\ldots(44)$$

If $k=1$, $t=1$, and if $(C^1 - D) = C$, then

$$X = C + \frac{M}{r} + \frac{C}{(1+r)^n - 1} \quad \ldots\ldots\ldots\ldots\ \ldots\ldots\ldots(45)$$

In permanent structures the term R reduces to zero and we have the simple formula:

$$X = C + \frac{M}{r} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(46)$$

If only a portion of the structure is permanent, then the term $C^1$ represents the cost of renewal of the part which is not permanent.

Example.

The construction cost of certain waterworks of a city is estimated at $500,000, one-half being considered permanent, one-quarter to have a life of 20 years, and one-quarter a life of 50 years. Annual cost of operation and repairs equals $20,000. The rate of interest is assumed to be 4 per cent, compounded annually. What is the capitalized cost?

First cost=C=$500,000.

Repairs at end of 20 years=$125,000; renewal fund=

$$\frac{125{,}000}{(1.04)^{20} - 1} = \$104{,}945.00$$

Repairs at end of 50 years=$125,000; renewal fund=

$$\frac{125,000}{(1.04)^{50}-1} = 20,470.30$$

Maintenance fund= $\frac{20,000}{.04}$ = $500,000

Hence total capitalized cost=

$$500,000 + \frac{125,000}{(1.04)^{20}-1} + \frac{125,000}{(1.04)^{50}-1} + 500,000 =$$

$1,125,415.30.

COMPARISON OF COST ON BASIS OF ANNUAL EXPENSE.

The annual expense will consist of: (1) the annual interest on the first cost=I; (2) the amount that must be spent annually for maintenance=M; (3) the amount that must be set aside annually and placed at compound interest to provide for renewal at the expiration of the life of the article = $B = \frac{(C^1-D)r}{(1+r)^n-1}$ See formula (14).

Hence the total annual expense = I + M + B

$$= Cr + M + \frac{(C^1-D)r}{(1+r)^n-1} \qquad (47)$$

It will be noticed that this is the same as Xr or the annual interest on the capitalized sum previously found.

The last term in formula (47) may be called the annual depreciation. The annual depreciation per unit of cost equals $\frac{r}{(1+r)^n-1}$

Example.

Two locations for a highway are under consideration. Route No. 1 is 10 miles long, will cost $2,000 per mile to construct it, and will require an outlay of $200 per year for maintenance. In addition to this, provision must be made for a $3,000 steel bridge, which probably must be renewed every 15 years (scrap value= $500, say). Route No. 2 is 11.2 miles long, will cost $1,600 per mile to build it and $325 per year for maintenance. A bridge will also be needed, which should be made of reinforced concrete, a permanent structure, costing $6,000.

With compound interest at 4%, which route will be the more economical?

Annual expense of route No. 1=

$$(20,000+3,000)\times.04+200+\frac{(3000-500)\times.04}{(1.04)^{15}-1}=\$1,244.85$$

Annual expense of route No. 2=

$(17,920+6,000)\times.04+325=\$1,281.80$

Hence route No. 1 would be slightly cheaper.

EXAMPLE.

Suppose a city with a population of 15,000 persons invests in a water supply system costing $600,000 and the annual operating expenses are as follows:

| | |
|---|---|
| Fuel and oil | $20,000 |
| Salaries | 12,000 |
| Supplies | 3,000 |
| | $35,000 |

The annual renewal and depreciation fund will be taken as 8% of the cost of the plant.

Bonds, redeemable in 20 years, are issued with interest at 5%. The increase of population is likely to double in 20 years, but it will be assumed that future needs can be provided for by additional pumps and that their cost will have the same relation to the increase in earnings as the original cost has to the present income, hence provision for future enlargement of plant will not be considered in the problem.

The water consumption will amount to 100 gallons per person per day. It is required to determine the selling price of 1,000 cubic feet of water and the annual cost per capita.

The annual revenue necessary embraces the following:

| | |
|---|---|
| Sinking fund to pay the bonds 20 years hence $=\frac{600,000\times.05}{(1.05)^{20}-1}$ | $18,145 |
| Interest on bonds=$.05\times600,000$ | 30,000 |
| Operating expenses | 35,000 |
| Renewal and depreciation fund = $.08\times600,000$ | 48,000 |
| | $131,145 |

Annual cost per capita $= \frac{131,145}{15,000} = \$8.76.$

Water consumption per year $= \frac{15,000 \times 100 \times 365}{7.48}$

$= 73,200,000$ cubic feet.

Cost per 1,000 cubic feet $= \frac{131,145}{73,200} = \$1.79.$

COMPARISON OF COST OF TWO ARTICLES ON BASIS OF EQUIVALENT CAPITALIZED COST.

Let $X^1$ = capitalized cost of one article.
$X$ = " " " other "

Assume the cost of renewal equal to the first cost, then, using formula (45):

$$X = C + \frac{C}{(1+r)^n - 1} + \frac{M}{r} = \frac{C\,(1+r)^n}{(1+r)^n - 1} + \frac{M}{r}$$

Similarly, $X^1 = \frac{C^1\,(1+r)^{n'}}{(1+r)^{n'} - 1} + \frac{M^1}{r}$ where C is the cost of one article of life of n years and $C^1$ is the cost of the other article with life of $n'$ years.

Letting $X = X^1$ and solving, we have:

$$C = \left[\frac{C^1\,(1+r)^{n'}}{(1+r)^{n'} - 1} \times \frac{(1+r)^n - 1}{(1+r)^n}\right] + \left[\frac{M^1 - M}{r} \times \frac{(1+r)^n - 1}{(1+r)^n}\right] \qquad \text{(48)}$$

Neglecting the cost of maintenance, that is, letting $M^1 - M = 0$, we have

$$C = \left[\frac{C^1(1+r)^{n'}}{(1+r)^{n'} - 1} \times \frac{(1+r)^n - 1}{(1+r)^n}\right] \qquad \text{(49)}$$

Example.

How much may be paid for a crosstie lasting 16 years to show the same merit as a tie lasting 7 years and costing 55 cents, interest at 5%?

$n=16,\ n'=7,\ C'=0.55.$

Using formula (49),

$$C = 0.55 \times \left[\frac{(1.05)^7}{(1.05)^7-1} \times \frac{(1.05)^{16}-1}{(1.05)^{16}}\right] = \$1.03.$$

This shows that a railway company could afford to spend \$0.48 per tie for treatment with some preservative oil in order to make the ties last 16 years instead of 7 years.

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# WALDEN'S INVERSION

BY ALVIN S. WHEELER.

During the years 1896 to 1899 P. Walden[1] published observations upon the behavior of optically active substances which were the most surprising in this field since the fundamental researches of Pasteur. The discoveries of Walden showed that it was not necessary to pass from an optically active substance to its racemic form in order to reach its antipode. He found that this inversion may take place directly. After 1889 Walden published no further work in this line nor did any one else pay attention to this unexplained phenomenon until 1905 when E. Fischer and O. Warburg[2] showed that the process could be employed with amino acids. The most important of Walden's researches is exhibited in the scheme below which shows a cycle of changes. It is seen that the sign of rotation of the active chlorosuccinic acid and malic acid may be interchanged at will.

| | | |
|---|---|---|
| l-chlorosuccinic acid | $\xleftarrow{PCl_5}$ | d-malic acid |
| $\downarrow Ag_2O$ | $\xrightarrow[KOH,\ NH_3]{}$ | $\uparrow Ag_2O$ |
| l-malic acid | $\xleftarrow{KOH,\ NH_3}$ | d-chlorosuccinic acid |
| | $\xrightarrow[PCl_5]{}$ | |

The change of configuration was named by Fischer the Walden Inversion. If a reagent causes no change in the configuration, it

1. Ber. d. deutsh. Chem. Ges. **29**: 1896; **30**: 2795, and 3246. 1897; **32**: 1833 and 1855. 1899.
2. Ann. Chem. (Liebig), **340**: 191. 1895.

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is said to act normally, whereas if it causes a change it acts abnormally. Owing to the uncertainty at times of the real configuration, it remains a matter of opinion whether a reagent acts normally or abnormally. It appears however that a single reagent may act in both ways, as Fischer has observed in the case of nitrosyl bromide which acts differently upon α-amino acids and their esters.

d-alanine + NOBr ———> l-bromopropionic acid

d-alanine ester + NOBr ———> d-bromopropionic ester

He also observed[3] a difference in the product with silver oxide.

l-bromopropionic acid + $Ag_3O$ ———> l-lactic acid

l-bromopropionylglycine + $Ag_2O$ ———> d-lactic acid

McKenzie and Clough[4] have noted recently that similar reagents may act differently. They found that l-hydroxy-phenylpropionic acid was converted by thionyl chloride into l-cloro-phenylpropionic acid whereas phosphorus pentachloride gave the dextro form.

All observations until recently have been confined to α-substituted acids. Lately Fischer and Scheibler have studied l-β-hydroxybutyric acid but were unable to prove an inversion. These authors announce the forthcoming publication of the observation that the hydroxyacid obtained from β-aminobutryic acid by the action of nitrous acid is optically different from that obtained by way of the chlorbutyric acid by the action of nitrosyl chloride. So far as noted the Walden Inversion is dependent upon the presence of a carboxyl group and the reactions are limited to the displacement of an amino group by means of a nitrosyl halide and to the displacement of a halogen group by an hydroxyl group or vice versa. Although there remain still many gaps to be filled, Fischer[5] has suggested an explanation of the phenomenon. As may be seen from the statements above, a Walden Inversion takes place when the configuration of the molecule changes as a result of substitution on an asymmetric carbon atom. Fischer believes that the inversion is a general phenomenon related very intimately to the mechanism of substitution. Whether a substitution is followed by a change in configuration depends upon the nature of the reaction and on that of the atoms linked to the

3. Ber. d. deutsch. Chem. Ges., **40**: 494. 1907.
4. Jour. London Chem. Soc., **97**: 2546. 1910.
5. Ann. Chem. (Liebig) **381**: 123. 1911.

asymmetric carbon atom. Since the antipodes possess a like energy content and therefore a like stability, there is an equal probability of either isomer being formed. The changes may be readily comprehended by the use of a new type of model devised by Fischer The carbon atom attached to an iron rod is entirely covered with steel bristles. The substituents consist of variously colored celluloid balls attached to corks which are covered on one side with steel bristles. A special system of two corks joined together and having three bristle surfaces is designed to represent subsidiary valencies. The mechanism of the changes is illustrated by employing the conversion of α-bromopropionic acid into the corresponding active amino acid by means of liquid ammonia, regarding the addition compound as consisting of one molecule ammonium α-bromopropionate and one molecule of ammonia. The balls 1, 2, 3, and 4 (Fig. I) represent the four groups H, Br,

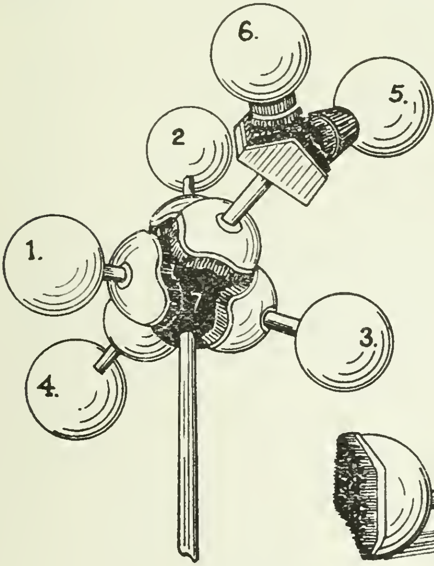


Fig. I.

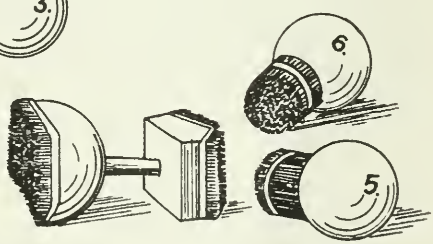


Fig. II

$CH_3$, and $COONH_4$, which are attached to the asymmetric carbon 7. The balls 5 and 6 signify the two parts of ammonia, H and $NH_2$ which are concerned in the substitution process. They are combined with the carbon atom by subsidiary valencies. The Figure II shows more clearly the arrangement of this group. If the halogen atom is set free and goes into the ionic form, the amino ($NH_2$) group may occupy its place. In this case no change has taken place in the configuration of the molecule. It may happen however that one of the other three substituents, 1, 3 or 4, will occupy the place of the halogen, leaving its place for the amino group. Here the configuration is changed and the Walden Inversion has taken place. If however both processes go on, then either a partial or a complete racemisation will occur.

The experimental part of this paper describes a Walden Inversion carried out by the author[6] in the chemical laboratory of the University of Berlin with E. Fischer and H. Scheibler. α-Bromoisocapronic acid was converted into the hydroxy acid, known also as leucine acid. We were able to resolve this into its active constituents with brucine, quinine and chinidine, the salt crystallizing out in each case being the laevo form. Chinidine proved to be the best agent. The l-leucine acid was also obtained, for comparison purposes, from l-leucine, by the action of nitrous acid. The ethyl ester of both the racemic and the laevo acid were prepared. Attempts to substitute the OH group in the l-ester were unsuccessful, $PCl_5$ and $SOCl_2$ being tried. However it was readily substituted by Br by means of Br and red P. The bromoester proved to be dextro rotatory. The action of NOBr upon l-leucine gives l-bromoisocapronic acid which yields the l-ester. The following scheme of changes shows that a Walden Inversion has taken place.

l-leucine + $HNO_2$ ——> l-leucine acid ——> l-leucine ester

↓

l-leucine ——> l leucine ester + NOBr ——> d-bromoisocapronic ester

6. Ber. d. deutsch. Chem. Ges. **44**: 2684. 1911.

l-leucine + NOBr ——> l-bromoisocapronic acid ——> l-bromoisocapronic ester

## Experimental Part

*Preparation of dl-leucine Acid.* One hundred grams of α-bromoisocapronyl bromide in 1357cc normal caustic soda were automatically shaken at room temperature until complete solution took place and then heated several hours upon a water bath until all bromine was ionized. The solution was now neutralized with 194cc normal $H_2SO_4$, considerably concentrated upon the water bath, supersaturated with 120cc 5N-$H_2SO_4$ and repeatedly extracted with ether. After distillation of the ether a mass of crystals mixed with a sirup remained. The acid was purified by conversion into its diffiultly soluble barium salt, recrystallizing it, decomposing it with $H_2SO_4$ and extracting with ether. The yield amounted to 39.8 grams or 78 per cent of the theory. It may be recrystallized by dissolving in ether and precipitating with ligroin. The acid crystallizes in rhombic tables which if slowly formed are very large. The melting point is 76-7°. The purity was established by analysis.

*Resolution of dl-leucine acid into its optically active components.* Thirty grams of dl-leucine acid were dissolved in 500cc water and mixed with a solution of 84g(1 Mol )chinidine, containing alcohol of crystallization, in 299cc of alcohol. The solution was concentrated to about 500cc and kept 15 hours at room temperature after impfing. The yield of the chinidine salt amounted to 45 gr, much of which was racemic. After two recrystallizations from very weak alcohol the yield amounted to 39g or about one half of the theoretical amount. This gave an acid of the rotation, $(\alpha)^{20}_{D}=26.9°$ (in NaOH solution). This salt was nearly pure and was used for further work. The twice recrystallized, finely pulverized chinidine salt was shaken 15 minutes with an excess of normal NaOH. The filtrate from the separate chinidine was treated with an excess of $H_2SO_4$ and several times extracted with ether. After distillation of the ether the acid is recrystallized from ether + ligroin. It occurs in thin prisms and melts at 81-2°, with previous softening. The rotatory power of the sodium salt is greater than that of the free acid, the specific rotation being -27.8° as against -10.4°. The details of the analyses are here omitted. A pure dextro acid could not be obtained from the mother liquors, although it formed salts with other alkaloids. The highest rotation obtained was +11.9°.

*Preparation of l-leucine acid from l-leucine.* Five grams of l-leucine of rotation $(\alpha)_D^{20} = +15.8°$ (in a 5 per cent solution in a 20 per cent HCl) were dissolved in 57cc N-$H_2SO_4$ and treated at 0° with a concentrated solution of $NaNO_2$ (4g or 1.5 Mol.). The nitrite solution is added slowly during the course of a half hour. After standing 2 hours at 0° and three hours more at room temperature, the solution is extracted with ether and the hydroxy acid so obtained is converted into its barium salt. The acid thus purified had a rotation of $(\alpha)_D^{20} = -27.7°$. The yield amounted to 72 per cent of the theory. The action of nitrous acid is therefore smooth and proceeds without essential racemisation. The acid showed a melting point of 81-2°.

*Optically pure d-léucine acid* could not be obtained through resolution of the racemic acid but could be readily obtained by the action of nitrous acid upon d-leucine. The hydroxy acid so obtained gave melting point of 80° and a rotation of $(\alpha)_D^{20} = +26.3°$

*Ethyl ester of dl-leucine acid.* The method originated by Fischer and Speier was employed. Five grams of dl-leucine acid, dissolved in 15g absolute alcohol containing 0.22g HCl, were boiled 4 hours under a reflux condenser. The solution was pured into 5 parts of water, extracted with ether and the ethereal solution thouroughly dried over $Na_2SO_4$. After driving off the ether the ester distilled at 80-1° under 16mm pressure. The yield amouted to 4.85g or 80 per cent of the theory. The ester had a faint, pleasant oder, was difficultly soluble in water but easily in alcohol or ether.

*Ethyl ester of l-leucine acid.* The preparation of this ester was carried out exactly as that of the inactive ester. The properties were also the same. The rotation was $(\alpha)_D^{20} = -11.07°$. The ester yielded an hydroxy acid of rotation $(\alpha)_D^{20} = -26.9°$.

*Transformation of the ester of dl-leucine acid into the ester of d-α* *bromisocapronic acid*. Many attempts were made to substitute the OH group by Cl by means of $PCl_5$ and $SOCl_2$ but without success. The introduction of bromine however was readily carried out. Two and one half grams of the dl-ester were well mixed with 0.5g red P, cooled by a freezing mixture and 3.7g Br slowly introduced. A vigorous evolution of HBr immediately took place. In order to complete the reaction the mixture was allowed to stand at 0° for three hours and then 15 hours at room temperature. The product was treated with water and sodium bicarbonate with simultaneous introduction of ice. The reaction mixture was extracted with ether and the ethereal solution dried with sodium sulphate. After driving off the ether the ester was twice distilled. It boiled at 86-7° under 11mm pressure. The yield amounted to 1.25g or 36 per cent of the theory. The same experiment carried out with the *l-ester* yielded the *dextro ester* of α-bromisocapronic acid. The boiling point was 91-2° at 18mm pressure. Two grams of the l-ester gave 1.0g of the d-bromester or 3.6 per cent of the theory. The ester showed a rotation of $(\alpha)_D^{20} = +40.0°$, The rotation of the ethyl ester or l-α-bromisocapronic acid as given by Fischer[7] is $(\alpha)_D^{20} = -43.1°$. This value however is too small since the acid employed was 16 per cent racemic.

All determinations of the rotation of the free acids were carried out in NaOH solution and in sodium light. The experimental details for l-leucine acid, for example, are as follows: 0.1321g substance were dissolved in N-NaOH. The total weight of the solution was 1.3307 g and density at 20°=1.0144. The rotation at 20° and in sodium light in a 1dm tube was 2.88° (±0.02) to the left.

Chapel Hill, N. C.

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7. Ber. d. deutsch. Chem. Ges., **40**: 502. 1907.

# THE CREST OF THE BLUE RIDGE HIGHWAY

BY THOMAS F. HICKERSON.

Highways built primarily for scenic purposes are common in Switzerland, France, Germany, and many other countries of Europe, but they exist only to a limited extent in America, the most noted ones being the roads in Yellowstone Park, Yosemite valley, Adirondacks, the Crawford Notch Road in Newhampshire, and Vanderbilt's Road to Mount Pisgah.

The scheme for a scenic highway and a chain of hotels through the mountains of Western North Carolina, where the scenery is considered by many to be equal of any in the world, was thought out and put into effect through the efforts and influence of Dr. Joseph Hyde Pratt, State Geologist. The proposed location of this highway extends from Asheville to Boone, but the ultimate plen is to extend it, from Boone northward by Whitetop Mountain to Marion, Virginia, in order to connect with the Bristol-Washington Highway which passes by Roanoke and through the Shenandoah Valley, and Asheville southward by way of Hendersonville, Brevard, Toxaway, Highlands, Tallulah Falls, Ga., Cornelia, Ga., to a point on the National Highway, and thence to Atlanta.

There will be approximately 353 miles of the highway between Marion, Va. and Cornelia, Ga., nearly all of which lies in North Carolina. The following table gives the portions which are already graded and constructed etc.,

| SECTION | Distance. (Miles.) | Part already constructed. (Miles.) | Part which follows an old road that may need to be revised. (Miles.) | Part which has not been constructed. (Miles.) |
|---|---|---|---|---|
| Marion, Va., to Boone, N. C. | 75 | .... | 75 | ...... |
| Boone to Asheville | 134 | 52 | 6 | 76 |
| Asheville to Toxaway | 64 | 64 | ........ | ...... |
| Toxaway to Highlands | 28 | 28 | .... | ...... |
| Highlands to Tallulah F., Ga. | 30 | ..... | .... | 30 |
| Tallulah F. to Cornelia, Ga. | 22 | ...... | 22 | .... |
| Totals | 353 | 144 | 103 | 106 |

The total length of the Highway from Boone to Asheville, the part with which this paper deals, will be about 134 miles. Several sections have already been constructed, namely;

| | |
|---|---|
| Boone to Blowing Rock............ | 10 miles |
| Blowing Rock to Linville ......... | 22 miles (Yonahlossee Road) |
| Linville— Pineola— Grassland... | |
| Brushy Creek Gap ........ ........ | 13 miles |
| Mt. Mitchell Station to Little | |
| Switzerland ........ ........ ......... | 3 miles |
| Bull Gap to Asheville ... ... ... | 10 miles |
| Total .............................. | 58 miles. |

About six miles of the road between Linville and Brushy Creek Gap needs to be revised, hence the total length of road to be constructed equals 82 miles.

Sixteen weeks of the last two summers have been spent in making a survey of the territory between Linville and Asheville. The part surveyed during ten weeks of the summer of 1910 under the auspices of the North Carolina Geological and Economic Survey extends from Linville to Buck Creek Gap. There were ten men in the party besides the cook and camp boy, the chief engineer was Mr. W. L. Spoon, who was then State Highway Engineer. The other members of the party were: T. F. Hickerson, Transitman; J. M. Costner, Levelman; N. C. Hughes, Levelman; R. T. Brown, Front Rodman and Chainman; M. L. Lasitter, Rodman; J. F. Speight, Stakesman; P. M. Smith, Level Rodman; Alex Feild, Chainman; and C. C. Brown, Rodman. All of the party were University of North Carolina men except Lasitter and Speight, who were C E. graduates of the North Carolina A. and M. College. The party lived eight weeks in tents and two weeks in boarding houses. The two camp sites were near wagon roads and only a few miles from the C. C. and O. Railway so that supplies were easily obtainable.

The survey during six weeks of the summer of 1911, under the auspices of the Appalachian Highway Co., of which Dr. J. H. Pratt is president, starts at Bull Gap (a deep gap 10 miles east of Asheville and 2 miles from Rattlesnake Lodge, Dr. C. P. Ambler's summer home, where the party spent ten days very pleasantly) and extends to Step's Gap, near Mt. Mitchell. There were eight in the party in addition to the cook and camp box, as follows: T. F. Hickerson, Chief Engineer; R. T. Brown, Transitman; P. M. Smith, Levelman; N. S. Mullican, Rodman; S. E. Barbour, Front Rodman; Geo. Strong, Level Rodman; Arthur Ambler, Stakeman; McKinley Pritchard, Chainman. All the members of the party were from the University of North Carolina excepd the last two mentioned. This section of the mountains embracing a portion of "Craggy" and the "Blacks" averages about 5000 feet in elevation and is wild, rough, and inaccessible. There were no wagon roads and scarcely any trails that could be travelled in safety with a horse. Moving from place to place the camp equipment,consisting of seven tents, ten folding cots,clothes and two double blankets for each person, a stove, cooking vessels, table ware, rations, and numerous other things, was a problem of transportation more difficult than any of the party had ever met before, since everything had to be packed on mules or portaged a distance of about seven miles over steep and rough trails. There were three camps; the first at Carter's Field near Craggy, the second at Balsam Gap, the third at Toe River Gap.

This party also had in charge the location and constructien of a horseback trail from Bull Gap to Step's Gap. It follows fairly closely the site of the Highway, but for the most part lies nearer the summit of the ridges and peaks. Mr. William Palmer and his party built this trail two feet wide at a price of $50.00 per mile.

Since the Highway is to be primarily a scenic road for tourists it was located as near the summit of the mountains as the maximum allowable grade, directness, and feasibility of construction would permit. No grades will exceed 41 1-2 per cent (which means 41 1-2 feet per 100 feet or 238 feet per mile). The width of the road will be at least 20 feet. The surface will be of earth or gravel or macadam, the last being necessary at some places on account of the scarcity of dirt and the abundance of loose rock. Much of the located route lies on the north side of the mountain because it was found that there is less declivity and far less rock on northern than on southern exposures to the sun.

The instruments used in making the survey were as follows: Aneroid barometer, Pedometer, Abney hand level, Gurley transit, and Engineer's level. Topographic maps made by the United States Geological Survey were very successful as a guide.

The first step in the preliminary survey was a walking trip over a few miles of the territory for the purpose of getting a clear idea of the topography with reference to the selection of the best route. Barometer readings were taken at controlling points, such as low gaps and summits of ridges where the scenery is especially good. Hand level readings were taken here and there to determine roughly the grades to various points. The next step was the exact location, by means of the hand level, of the route outlined during the reconnaissance It often happened that several trial lines had to be run before the most feasible route could be determined. Huge solid rock cliffs with almost vertical faces were often encountered. This necessitated either a raising or lowering of the grade line in order to dodge them. Fortunately this was done in every case without exceeding a 4 1-2 per cent grade. In several places narrow ledges of solid rock could not be avoided and hence considerable blasting will be necessary for short distances.

Loops were resorted to as seldom as possible and were always located so that the turn was made on comparatively flat ground where excessive excavation would not be required. In about a dozen places between Linville and Asheville loops were introduced to reach a low gap, or cross a ridge, or surmount a rock precipice.

When the most suitable route was finally established after due consideration had been given to directness, economy of construction, and scenic advantages; the transit, level, and cross section parties came along with two or three axemen and made an accurate instrumental survey of the located line, so that a map showing the plan, longitudinal profile, and transverse profiles at intervals of 100 feet can be drawn, from which an estimate of the cost can be made. Notes were made of stream crossings, property lines, character of the soil, amount of rock, extent of forest and open ground, and all points of interest.

The average grade along the whole location is about 4 per cent. This means that there are practically no level grades. If two gaps, one mile apart, had the same elevation it would make the route more direct in most places to run up on 4 per cent. half way and down on 4 per cent. half way instead of running on a level the whole distance, on account of the fact that the spur ridges and coves are much wider and deeper lower down on the mountain.

The maximum and the average altitudes of the various sections of the Highway between Boone and Asheville are as given below:

| SECTION | Distance. (Miles.) | Max. Elev. (Feet.) | Av. Elevation. (Feet.) |
|---|---|---|---|
| Boone to Blowing Rock | 10.0 | 3500 | 3360 |
| Blowing Rock to Linville | 22.0 | 4000 | 3800 |
| Linville to Altapass | 25.5 | 4100 | 3700 |
| Altapass to Little Switzerland | 6.5 | 3300 | 3000 |
| Little Switzerland to Buck Creek Gap | 12.5 | 3800 | 3500 |
| Buck Creek Gap to Step's Gap | 22.0 | 6200 | 4500 |
| Step's Gap to Craggy Fields | 13.0 | 6200 | 5700 |
| Craggy Fields to Asheville | 22.5 | 5500 | 3500 |
| Total | 134.0 | | |

The location from Asheville to Boone in detail is as follows: beginning at Asheville, the proposed highway coincides with the road to the top of Sunset Mt., for a distance of five miles. A detailed description of this road, as seen in "The Manufacturer's Record," October 26, 1911, is as follows: "An exclusive automobile road, nearly all of which is 3 per cent. grade, with none greater than 5 per cent., beginning at the foot of Sunset Mt., near the end of Charlotte street, Asheville, and winding around the face of the mountain to its summit, has just been opened to the public by Dr. E. W. Grove of Asheville and St. Louis. The entire length of the road to the summit has been laid with macadam. There are signs at approaches to all curves to "Blow Horn", while at its intersection with the carriage road that also leads to the summit are signs giving notice that carriages are not allowed on this road. The carriage road over a different course also has signs advising the public that automobiles are not allowed on it. The distance from the center of the city to the summit of Sunset Mt. over this road is five miles, and motoring over its smooth surface presents to the eye views of rare sublimity and grandeur. The consummation of the tourists enjoyment is attained when the summit of the mountain is reached. Here, at an altitude of 3119 feet above sea level and nearly 1000 feet above the c'ty, is a spread of vernal beauty that encompasses rare delights of valleys and summits, and in the full look across the Asheville plateau there is a world of grandeur and a loveliness of setting that stretches away to the far off mountains in the west, where the majestic peaks of Pisgah, Richland Balsam, Cold Mountain and the Bald pierce the sky at altitudes of 5749, 6540, 6000, 5400 feet, respectively, with a dozen others ranging in height from 3100 to 5000 feet This automobile road connects at the Summit of Sunset with the Crest of the Blue Ridge Highway, which is to extend from Asheville to Blowing Rock, along the crest of the mountains, at elevations ranging from 3100 to 6200 feet above sea level."

Mr. E. W. Grove owns 700 acres of land including Sunset Mountan and intends building a big hotel on the summit of this mountain.

From Sunset Mountain the location extends to Bull Gap along an existing road which needs revision only for ½ mile; thence, around the north and west side of Richland Knob, Courthouse Knob, Lanes Pinnacle crossing ridges and curving in and out of coves to Potato Gap; thence, along the south side of Snowball Mt., through Carter's Field and onwards climbing a long loop on the western side of Craggy Knob to the edge of Craggy Fields, the favorite rendezvous for camping parties and the proposed site of a hotel; thence, through Craggy Gap around the west and north side of Craggy Pinnacle, the north side of Craggy Dome to the gap between the Dome and Bull Head; thence, up grade following near the summit of Bull Head Ridge for ½ mile reaching an elevation of 5700 feet, and then down grade with a succession of loops along another ridge, (locally known as Peach Orchard Ridge) leading to Palsam Gap, the beginning of the Black Mountain Range, and the dividing line betwean the Asheville water-shed on the west containing 13,000 acres of magnificent timber consisting mostly of balsam which still make hiding places for a few bear and deer; thence, winding around the north side among the beautiful balsams, and following along the east side of Blackstock Knob in full view of Mt. Mitchell, the north side of Potato Knob, Clingman's Peak, Mt. Gibbs, to Step's Gap at an elevation of 6200 feet and about $1\frac{1}{2}$ miles from the summit of Mt. Mitchell. This is the nearest point on the proposed highway to the Peak, but during the past summer a survey was made by Messrs. Chisholm and Osborne of Charlotte for a highway from Black Mountain (on the Southern Railway) up Walkertown Ridge along the east side of Graybeard and the Pinnacle of the Blue Ridge through Toe River Gap and Step's Gap to the west of Hallback and around the west side of Mt. Mitchell upwards to its summit.

The Mitchell monument, which is a zinc shell filled with loose rock, is the first thing of interest on the top of the mountain. The inscription on the monument is as follows: "Here lies in hope of a blessed resurrection the body of the Rev. Elisha Mitchell, a Professor in the University of North Carolina, who lost his life in the scientific exploration of this mountain, in the 64th year of his age, June 27, 1857."

The ownership of Mt. Mitchell is in dispute. The Connelly heirs have probably the best claim. A log cabin with a kitchen in one end and bunks in the other, was built on the top of this mountain during the past summer.

The section from Step's Gap by way of Toe River Gap to Buck Creek Gap has not yet been surveyed, though it is certain that it will follow somehow along the crest of the Blue Ridge from Toe River Gap eastward, in fact, the Blue Ridge will be followed all the way from here to Blowing Rock.

Beginning at Buck Creek Gap and running northeastward the location lies on the north and west side of the mountain until the summit is reached, it then follows along the crest of the ridge to the Blue Ridge Meadows; thence, mostly along the north side, around peaks, and across ridges to Gooch Gap; thence, through Bear Wallow Gap and by Little Switzerland to Gillespie Gap; thence, on a southern and eastern exposure partly along an old tram road built by the C. C. & O. Railway to McKinney Gap, which is ½ mile from Altapass, the highest point on the aforesaid railroad; thence, across a ridge along Rose Creek for a short distance and then by the way of Hog Gap upwards by windings and loops to the top of Hump Back Mountain; thence, along the top of Hump Back and down on the western side to Brushy Creek Gap, about 2 miles from Linville Falls; thence, by tne way of Altamont, Grassland, and Pineola to Linville; thence, along the Yonahlossee Road over the southern and eastern slopes of Grand-Father Mountain to Blowing Rock; thence, to the left of the Blue Ridge, along a graded road, which is at present a toll road to Boone.

Water is scarce along the route over Craggy and the Blacks. During the past summer, which was unusually dry in the mountains, several springs became dry. Sign boards giving the location of springs will be placed along the Highway.

Stone walls or wooden railings will be built along the edge of the road where the ground is dangerously steep below, also at the ends of loops.

The cost of building the 82 miles will amount to about $400,000 or roughly $5,000 per mile. The Yonahlossee road from Blowing Rock to Linville cost $1,100 per mile, and the road from Mt. Mitchell Station to Little Switzerland cost $3,300 per mile, but neither of these is wide enough. There is every reason to believe that this Highway will be completed within the next few years. Several railroads are interested and have promised to contribute liberally. Large amounts will be obtained from private subscriptions. Several of those living in the neighborhood of the road have already voluntarily offered to give as much as $500.

Every variety of scenery unsurpassed for its beauty and grandeur, comprising, as it will, extensive views into the Piedmont region, nearer views of deep valleys, and mountain tops, and ridges, with here and there a most attractive and beautiful waterfall and streams of clear crystal water penetrating the dense green forests, together with the invigorating air and refreshing breezes and other pleasures of local interest such as rhododendron, azalea, ferns, galax leaves, balsam, spruce, an abundance of chestnuts and huckleberries and wild strawberries, trout-fishing, etc., will afford infinite enjoyment to the tourist.

The section of the Appalachian Mts. through which the crest of the Blue Ridge Highway will pass contains the loftiest peaks east of the Rocky Mts., with mountain slopes covered with a more varied fauna and flora that is found in any other section of the country.

In ordor to get an idea of the superiority of the scenery in Western North Carolina over that in New England we may note the following, from S. M. Dugger's book on "The Balsam Groves of the Grandfather Mountain".

Highest summit east of the Mississippi, Mitchell's Peak
in North Carolina................................altitude, 6,711 feet,
Highest mountain in New England, Mount Washington
in New Hampshire.................................altitude, 6,285 feet,
difference, 426 feet.

Among the peaks jointly possessed by North Carolina and East Tennessee there are 23 which surpass Mt. Washington in height. In addition to these, there are 23 other mountains which exceed 6000 feet, but fall short of Mt. Washington; and there are still 79 others which exceed 5000 feet, many of them closely approximating 6000.

The completion of this "Crest of the Blue Ridge Highway" will render possible wonderful developments in the agricultural, mineral, forest, and water power resources of the mountains, besides attracting thousands of pleasure-seeking tourists. As a purely scenic highway, it is destined to become one of national importance.

Chapel Hill, N. C.

# THE PLANT LIFE OF HARTSVILLE, S. C.

BY W. C. COKER

## INTRODUCTION

South Carolina has been the home of several of the most prominent botanists of America. Thomas Walter, an Englishman by birth, who lived on the Santee River in the upper part of St. John's Parish; Stephen Elliott, of Charleston; H. W. Ravenel, of Pinopolis and later of Aiken,—these are honored names in the history of our science; nor are they by any means all who have made valuable contributions to the botany of the State. Dr. Francis Peyre Porcher, Dr. James McBryde, Dr. J. H. Mellichamp, and Prof. Louis R. Gibbes were all native South Carolinians and careful students of its flora. All of these men lived and worked in the lower half of the State, in fact all but two entirely below the Santee River. With the exceptions mentioned below, the flora of the northern and northeastern parts of South Carolina was left without any particular study, and knowledge of its composition has been largely a deduction from what was reported from similiar or adjoining areas. There is much work yet to be done before the composition and distribution of even the higher plants of the State can be said to be at all well known. Mr. Ravenel and Dr. M. A. Curtis did considerable work in the fungi, but with these exceptions the lower plants have been studied scarcely at all.*

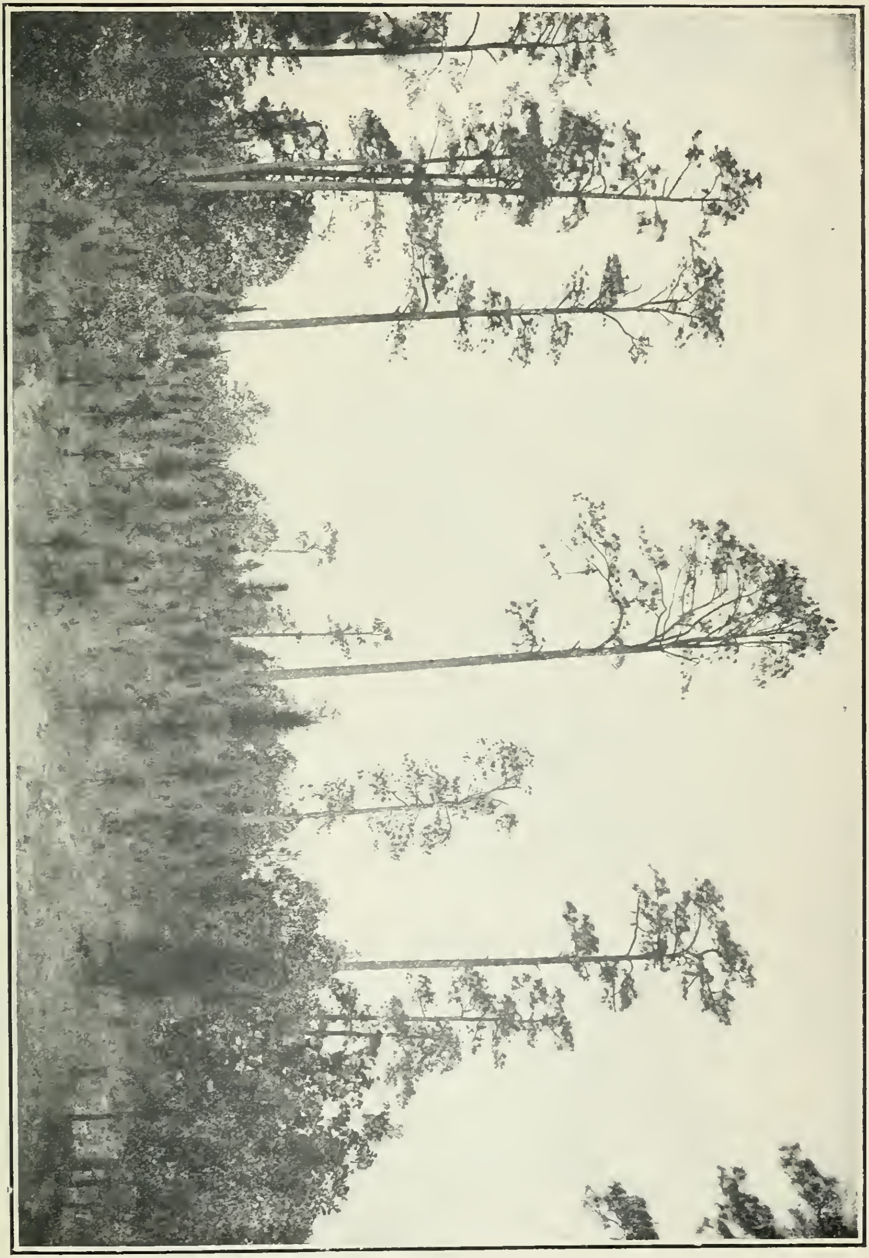
No catalog of the plants of South Carolina has ever been compiled. Elliott's book was called "A Sketch of the Botany of South

*Observations on the vegetation of South Carolina by the pioneering botanists of the early days,—travellers like Catesby, Bartram and the two Michauxs,—are of much interest and value, but they can be mentioned here only in passing. See also my articles in THE JOURNAL OF THE ELISHA MITCHELL SCIENTIFIC SOCIETY, as follows: "A Visit to the Grave of Thomas Walter," Vol. 26, April, 1910. "The Garden of Andre' Michaux," Vol. 27, July, 1911. "Dr. Joseph Hinson Mellichamp," Vol. 27, May, 1911.

Carolina and Georgia,'' but none realized more than the author the necessary incompleteness of the work, especially for the upper part of the State. The local lists that have been published are those of Thomas Walter for the upper part of Berkeley County, of Prof. Gibbes for Columbia and environs, of Mr. Ravenel for the vicinity of the Santee Canal (being a part of Walter's territory), and of Dr. John Bachman for the neighborhood of Charleston.* At the end of his list of the more noticeable native and naturalized plants of South Carolina, in the volume on South Carolina published by the State Board of Agriculture in 1883, Mr. Ravenel gives the number of flowering plants known at that time in South Carolina as 1,810. A considerable number have been added since, and with a complete survey the total would probably reach over 2,100.

A history of the botanical work done in Darlington County can be written in a few words. As it lies somewhat off the direct line between Charleston and the North, or between Charleston and Columbia, few itinerant botanists have stopped in the district. Dr. Lester F. Ward passed through the county in 1895 and collected a few plants near the town of Darlington; and it is possible that Prof. Louis R. Gibbes of Columbia or Mr. H. W. Revenel may have picked up something here. However, I have not seen or heard of any specimens in their collections from this section. The botanical exploration of the county has been confined almost entirely to one man. Rev. M. A. Curtis, a gifted botanist of wide reputation, was for nine years (1847-1856) rector of the Episcopal church at Society Hill in the eastern part of Darlingten County, about seventeen miles from Hartsville. He gave his attention largely to fungi, and together with the Rev. M. J. Berkeley of England published a large number of new species in that group. However, he did not by any means neglect the flowering plants. He published no list of Society Hill

*In addition to these Dr. F. P. Porcher has published as a thesis for the degree of M. D., an extensive and valuable Medico-Botanical Catalogue of the "Plants and Ferns of St. John's, Berkeley, South Carolina;" and a paper by me on the Flora of the Isle of Palms, appeared in *Torreya* for August, 1905.



Young and old growth of Long-leaf Pine in the Sand Hills.

plants or any papers dealing exclusively with the flora of this region, but several new species of Angiosperms were described by him from Society Hill, among them being *Ilex Amelanchier* and *Baptisia Serenae*. Appreciation must also be expressed for the work of Mr. W. D. Woods, of Darlington, who through newspaper articles, correspondence and personal effort, has encouraged through a long life the study and preservation of our native trees.

## CLIMATE OF HARTSVILLE

The altitude of Hartsville is 214 feet, its latitude about 34° 4m and 2sec., its distance from the sea about eighty miles. The town has no station of the weather bureau and no records of consequence are at hand. The climatological data may, however, be approximately guessed at from the records of nearby stations. For this purpose I give below a table containing the more important records for several of our nearest neighbors:

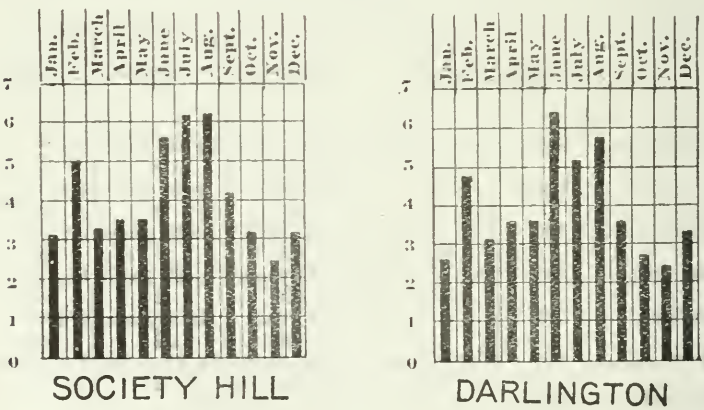
| | Altitude in Feet | Mean Annual Temperature | Highest Temp. | Lowest Temp. | Mean Annual Precipitation |
|---|---|---|---|---|---|
| Society Hill. | 192 | For 18 years 61.8 | In 18 years 100 | In 18 years 0 | For 17 years 49.31 |
| Darlington . | 155* | ? | In 6 years 101 | In 6 years 8 | For 13 years 47.26 |
| Cheraw....... | 144 | For 20 years 61.6 | In 20 years 104 | In 20 years 9 | For 21 years 47.66 |
| Columbia... | 351 | For 22 years 63.2 | In 22 years 106 | In 22 years 2 | For 26 years 46.62 |
| Camden .. | 222 | ? | In 4 years 100 | In 4 years 12 | For 42 years 44.18 |
| Aiken ......... | 565 | For 25 years 63.9 | In 25 years 107 | In 25 years 3 | For 26 years 46.43 |
| Hartsville .. | 214* | | | | |

From the data in this table the conditions at Hartsville may be very closely approximated. Darlington is about fourteen miles from Hartsville, Society Hill about seventeen miles, Camden about forty miles, but the temperature of the two last places is much nearer that of Hartsville than is that of Darlington. I would

*Elevation at the Atlantic Coast Line Railroad station as given by their survey. The weather bureau gives the altitude of Darlington as 175 feet. All other altitudes in the table are taken from the Weather Bureau reports.

guess that Hartsville is a little colder than Society Hill and the least bit colder than Camden. It is considerably colder than Darlington. As expressed by the vegetation there is a difference of nearly ten days in the coming of spring in Darlington and Hartsville, and there are some remarkable differences in the native vegetation. For example, the following coast plants are found wild or naturalized at Darlington but not at Hartsville: Carolina laurel cherry, or mock orange (*Prunus caroliniana*),‡ Darlington oak or laurel oak (*Quercus laurifolia*), Decumaria (*Decumaria barbara*) and Gray Moss (*Tillandsia usneoides*).† One small spray of the gray moss has been found hanging over Black Creek at Hartsville.

As the nearest available information in regard to the rainfall of Hartsville there are given below diagrams of the data for Society Hill and Darlington:




Diagrams showing the mean annual rainfall for each month at Society Hill (for the seventeen years preceding 1909) and for Darlington (for the thirteen years preceding 1909). From the U. S. Weather Bureau reports.

‡I know of about six trees of this species that have appeared spontaneously in or near the swamps and bays at Hartsville. In Darlington it has escaped abundantly.

†The non-occurrence of these plants at Hartsville is supposed to be due to a difference in climate. There are a number of others whose absence is due to soil characters, e. g., certain shrubs and trees of the Pee Dee Swamp.

There is no doubt that one of the principal factors influencing the distribution of species is the length of the growing season; and this may be determined by the mean occurence of the last killing frost in spring and the first killing frost in fall. The nearest stations to Hartsville for which this data is available are Cheraw and Florence. For Cheraw the average date of the first killing frost in fall is November 1st, and for the last killing frost in spring is April 5th. For Florence the dates are November 7th and March 31st. This would give a growing season of 209 days for Cheraw and 220 days for Florence. Hartsville's growing season would be nearer that of Cheraw's, say about 212 days.

There are no humidity records for this section of South Carolina, but I think there is no doubt that the humidity is less in the vicinity of the Sand Hills than in any other part of the State. It is almost certainly atmospheric dryness that accounts for the absence of the red cedar from this section, and that halts the gray moss at Darlington. The very rare occurrence, say once in twenty years, of cold waves that drop the temperature for a night or so to the neighborhood of zero seems to have little effect in determining the constitution of the flora. Length of growing season, atmospheric humidity, and mean lowest temperature are much more important.

The climatic position of Hartsville may be understood best, perhaps, when we consider the success or failure there of certain well known cultivated plants. A number of half hardy subtrophical species such as camellia (*Camellia japonica*), tea (*Camellia Thea*), camphor tree (*Cinnamomum camphora*), oleander (*Nerium oleander*), Cape jessamine (*Gardenia jasminoides*) may be successfully grown in the open, but our rarely occurring zero weather will injure them if unprotected. Oranges and other citrus fruits cannot withstand the average winters, but the new citrus hybrids, called Citranges, such as Morton, Willits, and Rusk, thrive and bear well.

## TOPOGRAPHY AND GEOLOGY.

Hartsville is situated on the exact inner edge of the upper drier part of the coastal plain, marking, therefore, the northern boundary of this great geographical division of the State. Just to the north of the town proper is the rapid descent of about 50 feet into the valley of Black Creek. This valley, with certain irregularities, extends for approximately one-half mile and is terminated on its northern edge by the outposts of the Sand Hills, which, gradually rising in gentle undulations, extend their barren prospect for miles to the northward. These Sand Hills are on the line that separates the Piedmont plateau from the coastal plain, and are a transition from one to the other. In their vegetation and geological origin they approach more closely to the character of the coastal plain. They were once much higher than they are at present, as is evidenced by the occurrence among them of a considerable hill, called Sugar-loaf Mountain, which rises to an elevation of 150 feet above the surrounding country and is capped by a layer of sandstone of sufficient strength to resist the extensive erosion that has elsewhere taken place. These hills mark the coast line of a Pleistocene sea that, shortly before the Glacial Epoch, halted here for thousands of years. An elevation then took place and the sea receded southward, exposing its level floor as our fertile and extensive coastal plain.

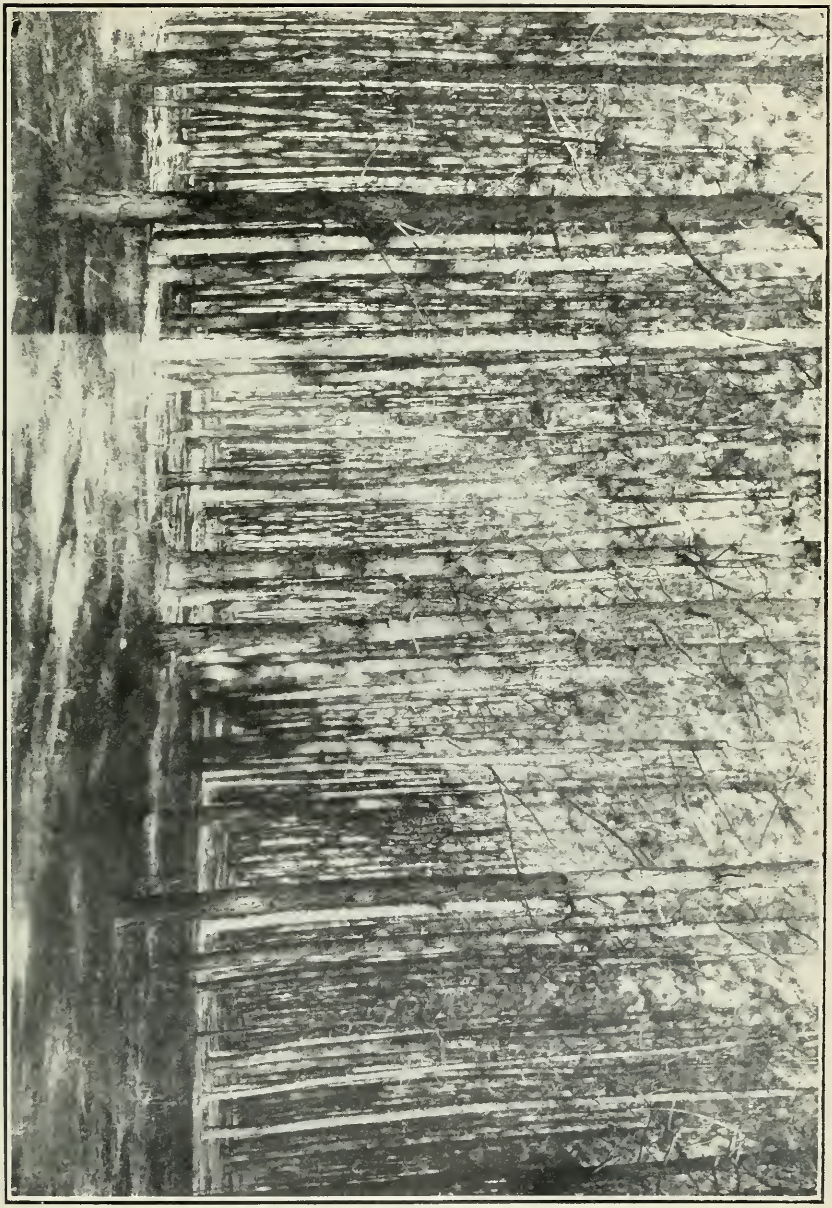
A cross section of the coastal plain in the neighborhood of Hartsville would show the following geological formations:

1st. RECENT. A surface layer of a few inches to a foot or more in thickness composed of a rather coarse gray, sandy loam, known as the Columbia sands.

2nd. PLEIOCENE? LAFAYETTE FORMATION, About 20 or 25 feet of variegated clays and sands, often highly and attractively colored. These may be seen at the big water cut across Home Avenue above Mr. McNair's place.

3rd. MIDDLE FRESH WATER CRETACEOUS: MAGOTHY FORMATION: Drab or black clays only a few feet in thickness, containing much lignite and vegetable matter. Many pieces of wood occur in this stratum, perfect in shape but very soft.

4th. LOWER FRESH WATER CRETACEOUS: POTOMAC FORMATION. This is the oldest of the coastal plain deposits, resting unconformably on the crystalline, igneous rocks below. It is characterized by absence of fossils, distinct banding, and the thickness of



Second growth of Long-leaf Pine in the Sand Hills.

its component layers of sands, clays, arkoses, gravels, etc. It is often stained with iron or other pigments, and mica is plentiful. It is from the sands of this formation that the artesian water that supplies the town is obtained. This water is as nearly pure as ground water can be, and its remarkable clearness and sparkle make it unsurpassed as a table water.

In the lower part of the county there is unterpolated between the Lafayette and the Magothy a deposit of Miocene marls of marine origin, and at places there are outcrops of this formation that have been worked for agricultural lime.

The general surface configuration of the country south of Black Creek valley is that of a remarkably level plain, with gentle elevations and depressions and occasional erosion cuts by the streams. As a result of this topography the surface drainage is often not good and open ditches are much used to empty pockets and lower the water surface in cultivated land. Except on a very few sandy knolls on the southern rim of the creek valley, that are really outposts of the Sand Hills, the nature of the vegetation on the level plain is determined very largely by the position of the water surface in the soil, and it is easily seen that the main ecological plant formations are dependent chiefly on this factor.

According to the United States Soil Survey of Darlington County there are in the immediate neighborhood of Hartsville five types of soils. The town itself is shown in their map as situated on the Orangeburg sandy loam, but there is evidently some mistake here* as this type is described in the text as containing "from 10 to 40 per cent. of water-worn pebbles, which rarely exceed the size of a man's thumb." As every one who lives in Hartsville knows, the soil does not contain such pebbles. Even the boy with the slingshot never found them out. This type is shown as extending to the foot of the hill towards the lake, and there being replaced by the Norfolk sand, which composes the flat valley, and with some interruptions extends up into the sand hills a mile or more, where it merges into the "Sandhill" type.

*The town really stands, I think, on the Norfolk sandy soil and the Goldsboro compact sandy loam.

The plantation immediately south of the town is of the Goldsboro compact loam type (according to the above-mentioned report), which may be said to correspond roughly to the flatwoods.

The plant formation that I describe as Well Drained Upland Forest, which should include, I think, most of the area covered by the town and the hill slope to the north, seems to be typically characterized by the type of soil called Norfolk sandy soil by the Survey.

In describing the vegetation of the region it will be best to distinguish the principal plant formations and then to take up each in turn. Including the sand hills, streams and swamps, as well as the various distinctive areas of the level uplands, we may distinguish in the vicinity of Hartsville as many as six ecological divisions or areas, as follows:

1st—THE SAND HILLS, OR PINE BARRENS.

The soils are extremely porous and composed very largely of sand, the surface specimen analyzed by the U. S. Soil Survey showed 94.78 per cent. coarse and fine sands and only 0.77 per cent. of organic matter. The subsoil is a yellow sand of the same texture, and of slightly higher clay content. In lower spots the proportion of humus is much greater and the soil is denser and damper.

2nd—THE WELL-DRAINED UPLAND FOREST.

The soil is that of the Norfolk sandy loam which is described as follows by the Survey:

It "consists of from 12 to 24 inches of a gray sandy loam, not unlike the soil of the Goldsboro compact sandy loam. A superficial examination might not suffice to distinguish the two types, but the subsoil gives rise to a variation in crop production which is quite evident. This subsoil is a sticky yellow loam or clay, which contains enough medium and fine sand, however, to render it much more friable than the subsoil of the Goldsboro compact sandy loam.

"There are a few areas of this type bordering large sand tracts, but its normal occurrence is as a narrow border, varying in width from one-half mile to two miles along the smaller streams. As the stream is approached the sandy soil becomes deeper and the subsoil lighter in texture.

"On account of the position of this soil the drainage is generally good. The uncleared areas support a heavy growth of pine and the various hard woods common to the uplands of this section."

When cleared it makes an excellent type of farm land, but on account of the rather coarse texture it is somewhat inferior to certain of the more compact soils.

3rd—THE POORLY-DRAINED FLAT-WOODS.

These areas are somewhat lower than the preceding ones and are so extremely flat that the drainage is poor. The soil is Goldsboro compact sandy loam, and is thus designated by the Survey:

"The surface soil is an ashy-gray sandy loam, 10 to 20 inches in depth. There is usually a slight stickiness and coherency in this sand which distinguishes it from the [s]oil of the Norfolk sand. The subsoil is a tenacious and rather impervious clay loam, varying in color from yellow to dark gray. At lower depths the snbsoil becomes lighter in texture. The line of contract between soil and subsoil is well defined."

4th—THE SAVANNAS.

These conspicuous and interesting formations are undrained depressions in the flatwoods where the water stands at or above the surface for a considerable period of the year. The surface soil is a heavy, peaty, sandy loam and the subsoil is generally a dark gray sticky pipe clay that is almost impervious to water. In colder climates the savanna would probably be a Sphagnum bog.

5th—SWAMPS.

These may be devided into two sorts: the Shallow Swamps or Bays (often called "Galls" or "Gall Bays"), and the Deeper Swamps; and the Bays may be further divided into the alluvial or typical Bays and the non-alluvial or Flat-woods Bays. The typical Bay is a low, wet, alluvial area of deep, fertile, more or less muddy soil, rich in humus, with a pervious subsoil and some surface drainage. In the lower areas slowly moving surface water is generally present in pockets and runs between the tussocks. The non-alluvial or Flat-woods Bay is a formation that occupies an intermediate condition between the Flat-woods and the Savanna. There is no drainage and the distinction is one of water content of the soil. The surface of the ground is almost saturated in rainy seasons, and damp and dry seasons, and the vegetation is quite different from either the Savanna or the Flat-woods. This is the formation that is called a "pocosin" in eastern North Carlina, although the term is used sometimes, it appears, to include the alluvial Bay (see Harper, Bull. Torrey Bot. Club, Vol. 34, page 361). The Deeper Swamp is like the alluvial Bay except that the surface is under water for a good part of the year. The bays are not subject to inundation and scouring from stream freshets and the deeper swamps are, and in its effect on the vegetation this is perhaps the most significant difference between them.

6th—STREAMS AND PONDS.

Here the vegetation is aquatic and is either free floating or attached to the muddy or sandy bottom.

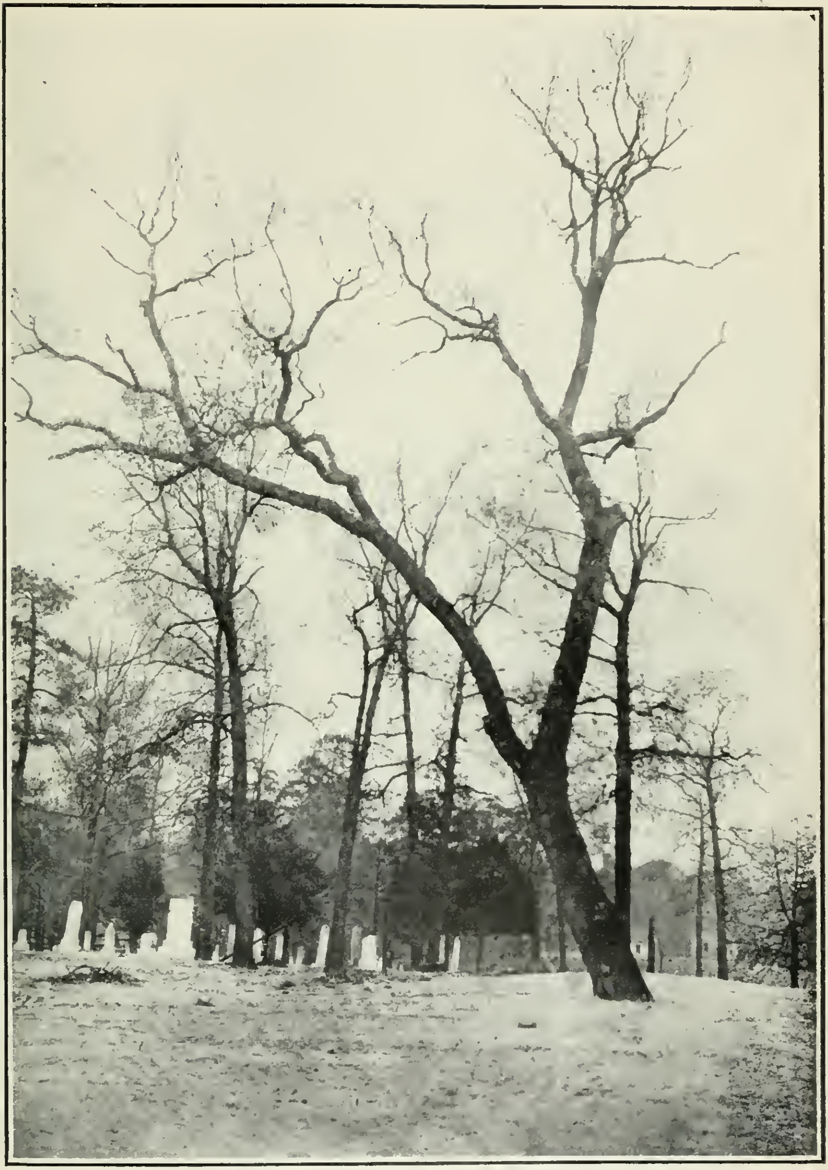
It will be best to take up the plant covering of each of these types in turn.

## VEGETATION.

### THE SAND HILLS.

The covering of these hills is a thin open forest of two stories—the upper one of long-leaf pine (*Pinus palustris*) towering high below the scrubby growth below. In the original condition the pines were moderately close, but not enough so as to cast a dense shade. The magnificent trees extend their spreading crowns at an altitude of 75 to 100 feet and seem more sure of themselves and more in character here than in any other place. And in reality it is only in these barren hills that the long-leaf pine is holding its own against the constant encroachment of the old-field pine that now seriously threatens its supremacy tn all other parts of the coastal plain. For many years all the destructive powers of man have been waged against this most admirable natural product of the Southern States, until now there is scarcely anywhere to be found in an undisturbed fragment of the original sand hill forest.

174



A large specimen of Turkey Oak (Quercus Catesbaei).

The pines have been boxed and burned and cut for sawing until they are now only thinly scattered over the hills. But fortunately they are reseeding themselves quite well in many places, and with the observance of the most elementary principles of forestry they could be renewed and increased indefinitely.

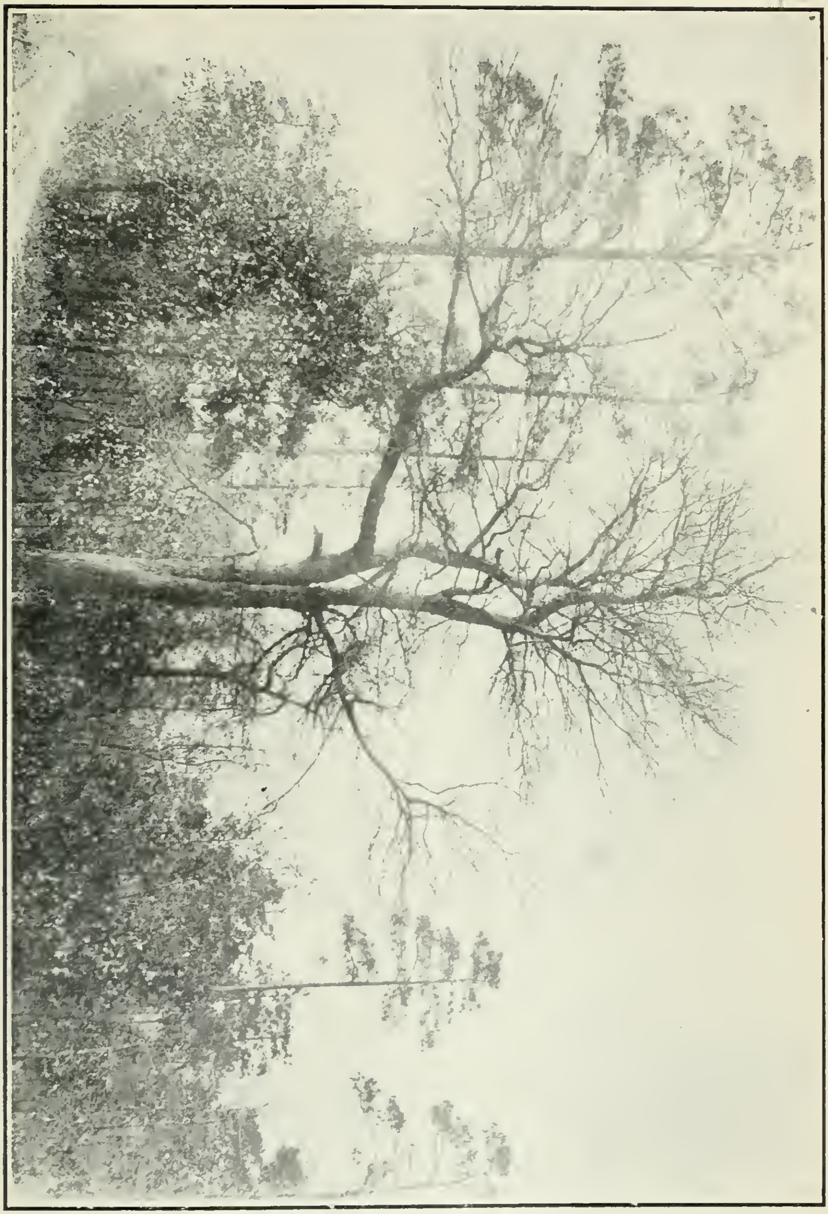
The frequent woods fires are still more or less destructive to the young plants, but after close observation for a number of years I am now convinced that the idea expressed by W. W. Ashe in several of his bulletins* that this species is more susceptible to injury by fire than the old-field pine is entirely erroneous. It is true that its growth is so slow that when five years old the bud is usually but a few inches above the ground, but the very dense and abundant protective scales of the bud are wonderfully efficient in keeping out the heat from the delicate growing point. Moreover, the widely spreading mat of long, succulent, mature leaves that rest on the ground prevents the accumulation of inflammable material near the bud and thus greatly reduce the intensity of the heat. Early in the spring of this year, when all buds were dormant, a severe fire ran over the woods between Burnt Bay and Prestwood's Lake. During the first week in June the ground was looked over carefully for evidence on this point. The woods are rather open and a large number of young long-leaf pine had gotten started. The mature leaves were killed back almost or entirely to the bud, and were largely burned off, but I could not find a single plant even though an inch high that was not putting out its fresh young leaves from the unhurt growing point. On the other hand, nearly all of the young plants of the old-field pine were killed and many of them were four to six feet high. It is of course true that year old seedlings of long-leaf pine cannot resist hot fires, and the destruction of very young plants in the way is doubtless a great deterrent at present to the reforestation of the sand hills.

Gifford Pinchot was the first to call attention to the superior adaptations of the long-leaf pine to fire resistance. In the National Geographic Magazine for October, 1899, page 298, he says:

*See Bulletins N. C. Geol. Survey, No. 5, page 58; No. 6, pages 157-165, and No. 7, page 16. In these bulletins Mr. Ashe gives an excellent discussion of the long-lenf pine problem and of the methods necessary to secure the continued propagation of the forests.

"Almost all trees yield readily to slight surface fires during the first ten or fifteen years of their life. To this statement the long-leaf pine is a conspicuous and rare exception. Not only do the young trees protect themselves in early youth by bark which is not uncommonly as thick as the wood (the whole diameter being thus two-thirds bark and one-third wood), but they add to this unusual armor a device specially adapted for their safety when growing amid long grass, usually a most fatal neighbor to young trees in case of fire. It is to be noted that the vast majority of long-leaf pines are associated with grass from the beginning to the end of their lives. During the first four or five years the long-leaf seedling reaches a height of but four or five inches above the ground. It has generally been erroneously assumed that this slow growth makes it specially susceptible to injury from fire; but while the stem during these early years makes little progress, the long needles shoot up and bend over in a green cascade which falls to the ground in a circle about the seedling. Not only does the barrier of green needles itself burn only with difficulty, but it shades out the grass around the young stem, and so prepares a durable fire-resisting shield about the vitals of the young tree."

In his little book on "The Long-Leaf Pine in Virgin Forest," published in 1907, G. Frederick Schwarz discusses this point and calls attention to the exceptional fire-resistance of the long-leaf pine after the first two or three years of growth. On page 71 he says: "Without attempting to minimize the immediate and serious harm done to young growth, it may be asserted that the destruction of long-leaf pine seedlings by surface fires has been somewhat exaggerated and misunderstood; at any rate, so far as concerns seedlings over two or three years of age." And which admitting that one or two year old seedlings are destroyed as a rule by fires he says (page 72): that "After the seedlings have attained several years' growth they begin to offer wonderful resistance to surface fires." In the Bulletin of the Torrey Bot. Club, Vol. 38, p. 523, 1911, R. M. Harper says: "It is pretty well known that long-leaf pine, after it is four or five years old, is less affected by fire than almost



Upland Willow Oak (Quercus Cinerea) in the Sand Hills.

any other tree we have, and in Southern forests periodically swept by fire little else can grow but this pine and a great variety of more or less xerophytic, mostly perennial, herbs, among which various grasses are usually most abundant."

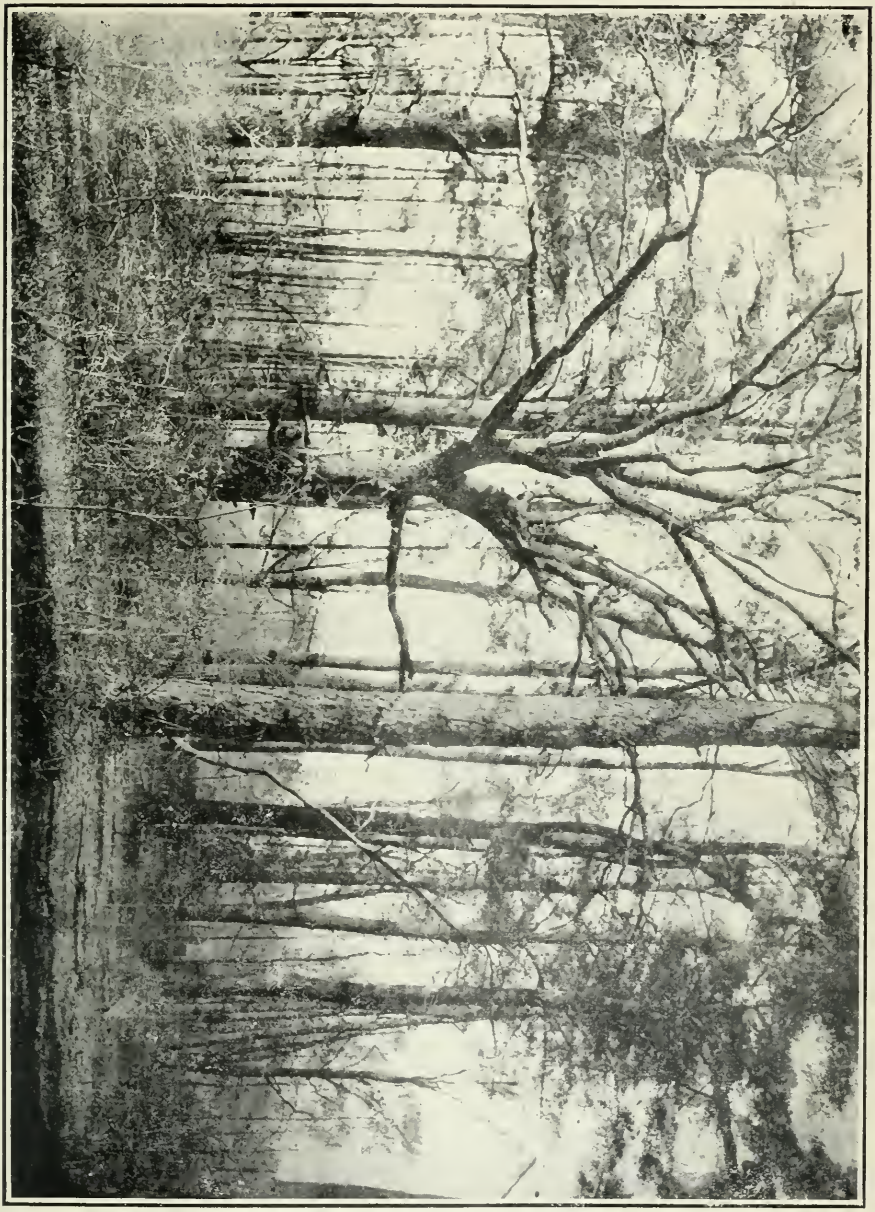
In the original condition of our forests the old-field pine was largely confined to the boundaries of swamps, bays and water courses. Over the remainder of the country the long-leaf pine was supreme. I think it probable that this condition was due principally to the fact that the long-leaf pine was able to endure the fires of the uplands, while the old-field pine was not. The latter was pushed aside to protected places. The present preponderance of second growth old-field pine in most thrown out land, outside of the sand hills, is probably due to two factors—1st, the infrequency of fires in cleared old fields, and 2nd, the insufficient seed production and limited seed distribution of the long-leaf pine. Given an equal chance and protection from fire and the old-field pine seems able to supplant the long-leaf pine from most of the good lands that it once occupied. It is different in the Sand Hills. There the soil is too poor to support the old-field pine and the long-leaf pine is given a free hand. Its present slow propagation there seems to be due as much to the scarcity and infrequent seed production of old trees as to fires, though these certainly do great damage, as mentioned above, in the destruction of young seedlings. The fact that the long-leaf pine can reproduce itself in the Sand Hills and is doing so abundantly in places is evidenced by the growth shown in Plates I and II.

Below the pines the rather low growth of the hills is composed most largely of several species of scrub oak. Among these the turkey oak, or fork-leaved black-jack, as it is more often called, (*Quercus Catesbaei*), is by far the most abundant, especially in the most barren places. It is almost always associated with broad-leaved black-jack (*Q. marilandica*), upland willow oak (*Q. cinerea*) and post oak (*Q. stellata*). The turkey oak and upland willow oak are typical sand hill species, but the other two occur also in more genial soils, where the latter reaches a much greater size. Though characteristically very small and scrubby the turkey oak may in the most favorable situations become a tree of considerable proportions—say 40 feet high and 2 feet in diamater. One of the largest I know of is that shown in Plate III near the Baptist Church building.

The upland willow oak is the smallest of all our species. The largest specimen I ever saw is shown in Plate IV (a winter view). It is about 25 feet high and 14 inches in diameter. The association of this oak as shown in the picture will give a good idea of what is characteristic of sand hill conditions. Tall long-leaf pines are scattered in the back ground, and in middle ground are small trees of turkey oak, black jack oak, post oak, a few stunted persimmons, choke cherries (*Prunus serotina*), and sassafras bushes. Poison oak (*Rhus quercifolia*) and summer grape (*Vitis aestivalis*) were the only other woody plants. In August, 1910, the flowers in bloom around this tree were *Vernonia graminifolia*, *Liatris pauciflora*, *Chrysopsis graminifolia*, *Dasystoma pedicularia* (fly poison) and *Ascyrum hypericoides*.

In the most barren knolls of the hills, where the sand is purest, about the only trees that can stand the conditions are the long-leaf pine and the turkey oak. And there is no shrub that can be said to be tolerant of such places. But where the slightest advantage in moisture is to be had the trees already mentioned can establish themselves, and a number of shrubs become characteristic components of the cover. Horse sugar (*Symplocus tinctoria*), stagger-bush (*Lyonia mariana*), sumach (*Rhus copalina*), and the summer grape (*Vitis aestivalis*) are frequent. The Carolina holly (*Ilex caroliniana*), a small shrub with large deep red, shiny berries, is also a member of this community, but it is rare, in fact one of the rarest Hartsville shrubs. It will grow in much damper soil, as for example in front of the Upper Farm Place on Home Avenue.

Bear grass (*Yucca filamentosa*) and rattlesnake master (*Eryngium aquaticum*) require slightly damper soil than the preceding group. They are usually to be found near the foot of slopes that descend to water courses and bays. But I have found the rattlesnake master in very dry places at times, and also in almost saturated soil. Another little shrub that can endure almost the extremes of both drought and moisture is the low black huckleberry



Pine and Oak woods below Captain Cannon's Residence.

(*Gaylussacia dumosa*). This plant can flourish under a remarkable range of conditions. It is as much at home on the damp edges of savannas, associated with *Lycopodium adpressum* and *L. carolinianum* as it is in the sand hills in company with the scrub oaks. Next to the pines and oaks there is nothing so at home in the sand hills as the wire grass (*Aristida stricta*). Its grayish-green, terete, wiry, recurved leaves form large tussocks thinly scattered in the sand. Frequently there is so little other growth that the pure white sand may be seen from a long distance shining under the trees.

The sand hills are not without their share of attractive flowers; in fact, with the exception of the savannas they are the most colorfull of the floristic regions of our section. In early spring all except the most barren places support a good display of violets and bluets (*Houstonia caerulea*), shoe strings (*Cracca virginiana*), and the dainty little dwarf iris (*Iris verna*). Arbutus (*Epigaea repens*) is also very frequent here, and lovely in early spring. Wild phlox (*Phlox Hentzii*) and the blue flowered lupine (*Lupinus diffusus*) are very conspicuous, but occur only rather sparingly in scattered patches. At several spots in the hills there have been discovered in recent years a number of colonies of that most charming little carpet plant, *Pycidanthera barbulata*, called flowering moss. It has been known before only from the pine barrens of New Jersey and North Carolina.* In summer there is a continuous series of bloom that reaches its height in August, with a number of conspicuous composits, such as *Chrysopsis graminifolia*, *Chrysopsis aspera*, *Chrysopsis pilosa*, *Vernonia augustifolia*, *Aster concolor*, *Silphium compositum*, *Coreopsis delphinifolia* and species of goldenrod.

Other characteristic herbs of the hills are *Stillingia sylvatica* (queen's delight), *Cracca ambigua*, *Cracca spiccata*, *Amorpha herbacea* (lead plant), *Indigofera caroliniana* (wild indigo), *Astragalus apilosus*, *Hieracium Gronovii*, *Carduus repandus* (thistle), *Breweria trichosanthes*, *Baptisia tinctoria*, *Asclepias tuberosa* (butterfly weed) *Tragia urens*, *Euphorbia Ipecacuana*, *Euphorbia Curtisii*,

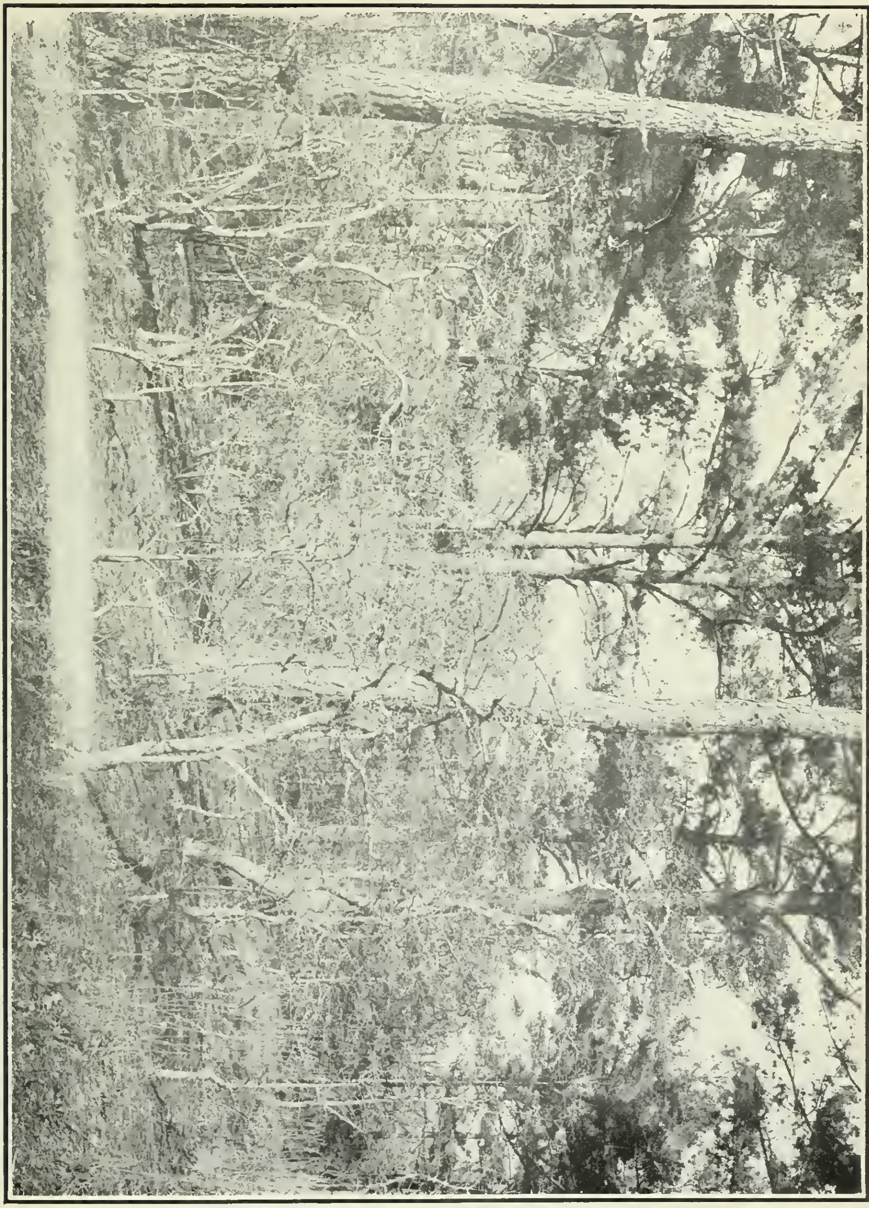
*See my article in Torreya, Vol. II, page 9, Jan., 1911.

*Euphorbia maculata*, *Penstemon laevigatus*, *Onosmodium virginianum*, *Paspalum setaceum* and *Stenophyllus capillaris*. There is a small sedge (*Cyperus Martindalei*) that is also abundant here, but it had not before been reported from the State.

### THE UPLAND FORESTS

The vegetation of the well drained upland forests of this section has been largely cleared away, but certain areas still remain that exhibit to some extent the primitive conditions. Originally it was as in the Sand Hills, a two storied forest with long-leaf pine as the dominant, but not the most abundant tree. Most of the pines have now been felled, but the vigorous and luxuriant growth of broad leaved trees that reached almost to the lower limbs of the pine crowns has been scarcely changed. The oaks are the dominant factor now, as they are in the Sand Hills, but are of different species. The Spanish oak (*Quercus falcata*) and black oak (*Q. velutina*) are the largest and by far the most numerous trees. Both of these oaks are of fine proportions, often reaching a height of seventy feet and a diameter of 3½ or 4 feet. Next in abundance come the post oak (*Q. stellata*) and white hickory (*Carya alba*). The former, which in the Sand Hills is scrubby or even bushy, is here a large tree, second only to the black, scarlet, and Spanish oaks. The scarlet oak (*Q. coccinea*) is a rare but beautiful member of this community. There is a very large old tree of this species on the lawn of the old Law Place (now the residence of Mr. A. M. McNair).

Among the smaller trees dogwood is abundant, and pignut hickory (*C. glabra*), persimmon (*Diospyros virginiana*), sassafras, and choke cherry (*Prunus serotina*) are frequent. There are few shrubs except in open places, where sumach (*Rhus copalina*), red-haws (*Crataegus uniflora*), cow itch (*Tecoma radicans*), and Jersey tea (*Caenothus americana*) are common. The slope of the hill towards the creek supports a fine forest which exhibits well the transition from the dryer to the damper well-drained soil. Its crown is covered with the growth just described, but on the slope there appear a few scattered trees of short-leaf pine and old-field



Sparkleberry (Vaccinium arboreum) under Old Field Pine (Pinus Taeda).

pine, and there is more dogwood (*Cornus florida*), choke cherry (*Prunus serotina*), sumach (*Rhus copalina*), and Jersey tea (*Ceanothus americana*). There were once a number of chinquapin bushes (*Castanea pumila*) on this hillside opposite Burnt Bay, but they are now nearly all gone.

At the foot of the hill behind the residence of Capt. E. W. Cannon there are several acres of well-drained fertile land that slopes gently toward the lake, and supports an untouched forest that exhibits well a slight modification of the conditions just described. In Plate V is shown a photograph of this spot. The old-field pines are very tall and fine and rise far above the hard-wood growth of oak, hickory, etc., with gums and holly near the lake. In the center of the photograph is shown a fine post oak with wide spreading branches. The lower woody growth is most conspicuous for its very fine dogwood (*Cornus florida*) and sparkleberry (*Vaccinium arboreum*). The latter is as luxuriant and abundant as I have ever seen it, and in places almost forms thickets, as shown in Plate VI. It here composes about all the undergrowth and is twelve to fifteen feet high.

Where the two paper mill roads go down the hill there are scattered specimens of the pretty little dwarf flowering locust (*Robinia nana*), one of our rarest shrubs. On newly deposited soil near gully washes, etc., one may occasionally find catalpa trees (*Catalpa bignonioides*) and red mulberry (*Morus rubra*), both probably introduced and not native. The bullace grape (*Vitis rotundifolia*) and the summer grape (*Vitis aestivalis*) are quite plentiful in these woods, as they are in most places that are not too wet. Wild "honeysuckle" (*Azalea nudiflora*) is also found here but is more at home in the flatwoods. As the foot of the hill is reached and the soil becomes more moist the appearance of holly, (*Ilex opaca*), yellow jessamine (*Gelsemium sempervirens*), horse sugar (*Symplocus tinctoria*), etc., indicates the transition zone to bay-margin conditions.

Beginning a little way above Captain Cannon's Place the swamp margin is bordered on the south side by more or less abrupt bluffs which may reach the entire height of the valley, as at the old Bacot Place. The vegetation of these bluffs represents the most northern element of our flora. Here is Mountain laurel (*Kalmia latifolia*) in profusion, and the rare combination may be seen of kalmia trees adorned with luxuriant vines of yellow jessamine. Perhaps the most interesting plant of these bluffs is colt's foot (*Galax aphylla*), which occurs in plenty in several places, and reaches here its seaward limit so far as I can ascertain. Spotted wintergreen (*Chimaphala maculata*), heart leaf (*Asarum arifolium*), partridge berry (*Mitchella repens*), arbutus (*Epigaea repens*), snake root (*Aristolochia serpentaria*), calamint (*Clinopodium carolinianum*), witch hazel (*Hamamelis virginica*), and sourwood (*Oxydendrum arboreum*) are attractive plants that occur here at their best. At two or three places along these bluffs, as at Laurel Land and below the paper mill, the remarkable little trailing huckleberry (*Vaccinium crassifoliam*), with firm, oval, evergreen leaves is found.

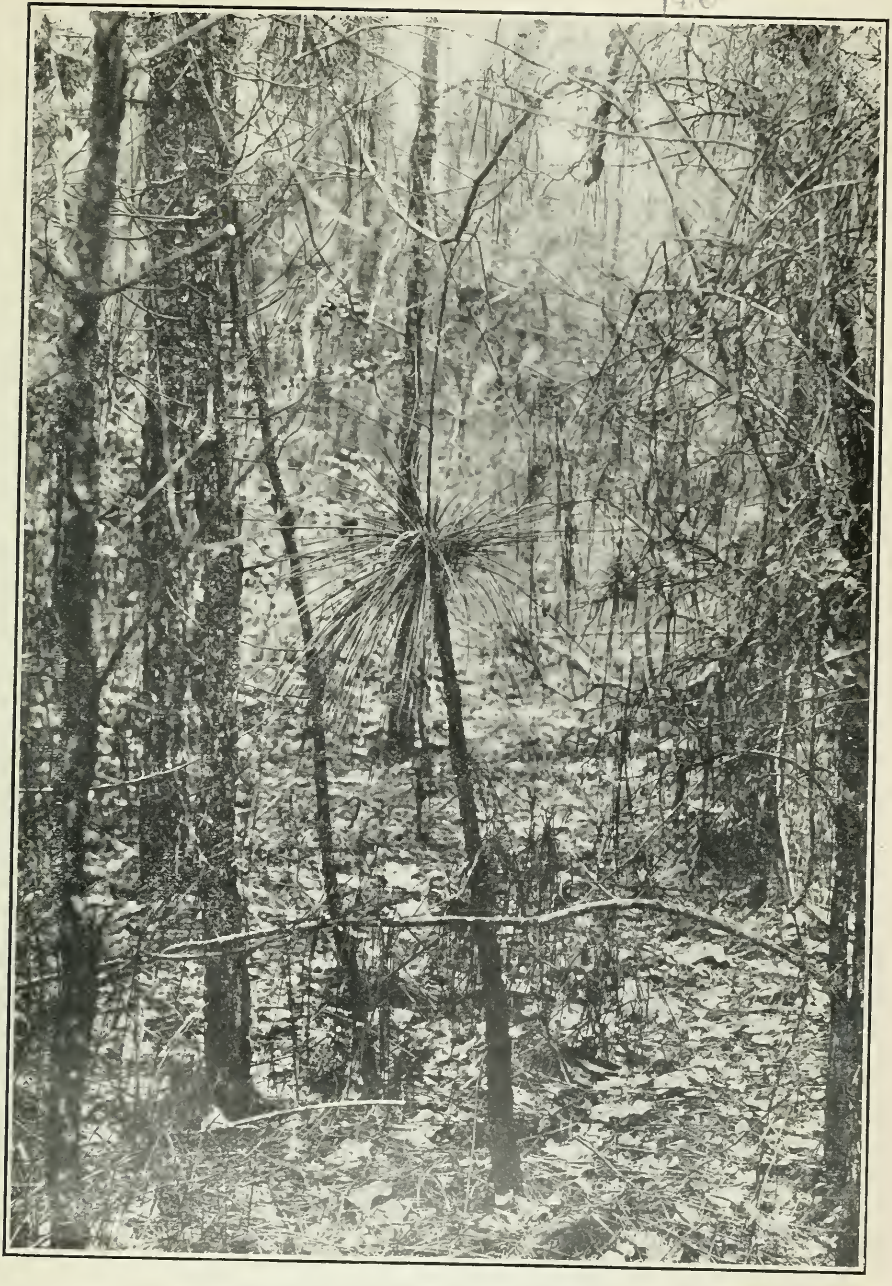
In Plate VII is shown the vegetation of these bluffs as it appears at Laurel Land. Mountain Laurel (*Kalmia latifolia*) is in the foreground, holly (*Ilex opaca*) and white oak (*Quercus alba*) in the background.

At the top of the high bluff behind the Bacot place there are a few escaped trees of mock orange (*Prunus caroliniana*) and Chinaberry tree (*Melia Azedarach*). As in the case of the peach, such occasional escapes as this do not entitle these trees to a place among the naturalized flora of the section.

To one accustomed to more northern conditions the most striking peculiarity of our rich woods is the almost entire absence of the conspicuous early spring flowers that show their attractive colors before the sun is cut off from them by the leafing of the trees. We have no anemones, hepaticas, or bloodroot, or giant chickweed, or spring beauty, or dogtooth violets (which are not violets at all). The hills and savannas have considerable color from herbaceous plants, but the deeper woods get most of their spring charm from the woody plants, as kalmia, yellow jessamine, dogwood, and azalea.

### THE FLATWOODS.

A transition from the well-drained forest to the more pronounced flatwoods may be noticed in the pine grove to the right of Home



Young Long-leaf Pine in dense shade.

Avenue, in front of the Upper Farm Place. Here for the first time we find a considerable amount of the short-leaf pine (*Pinus echinata*), and with it are associated long-leaf pine and old-field pine. Among these I was surprised to find a large tree of pond pine which is here in as dry a situation as I know of for the species (see Pond Pine under Hartsville trees). This is the only bit of level ground I have seen where these four coastal plain pines are to be found within a few yards of each other. Below the pines is a rather complete covering of shrubs and small trees. In addition to black oak and spanish oak there is water oak (*Quercus nigra*), willow oak (*P. Phellos*) and some black jack (*Q. marylandica*). One of the most conspicuous things about the grove is the large number of young holly (*Ilex opaca*) trees which are more abundant here than in any place I know of near Hartsville. The other trees are dogwood, white hickory, sassafras, choke cherry and persimmon. The shrubs are sparkleberry (*Vaccinium arboreum*), which is in great abundance, Carolina holly (*Ilex caroliniana*), red haw (*Crataegus uniflora*), and another species of *Crataegus* not yet determined. The perennial and almost shrubby little calamint (*Clinopodinum carolinianum*) is abundant. Yellow jessamine, bullace grape and summer grape are the only vines.

The re-seeding of the three species of pine in this grove is a point of considerable interest. There is abundant reproduction of the short-leaf pine, less of the old-field pine and a little of the long-leaf pine. Most of the young growth is in the more open places, but even in quite shady spots among the shrubs there are a large number of slender, delicate and struggling little short-leaf pine plants that grow about three inches a year and when ten years old are often not thicker than a lead pencil. Among the young long-leaf pines that were scattered here and there were some that were withstanding a shade so dense as to seem quite prohibitive to such sun-loving plants. One of these young trees is shown in Plate VIII. It is growing in a dense clump of sparkleberry bushes and short-leaf pine saplings. over which is a canopy of bullace grape vines. The extent of the shade is indicated by the occurrence around the foot of the pine of clumps of moss and of a number of plants of pipsissewa (*Chi-*

*maphila maculata*). This little pine is at least twelve years old and is only three feet three inches high, but it is far more stocky and vigorous than a number of young short-leaf pines near it, several of which had been killed by the shade. Another surprise was the finding in the same grove of a young long-leaf pine closely surrounded by hollys (*Ilex opaca*). In fact all one's previous experience in regard to the associations and requirements of the long-leaf pine seems controverted here.

Among the herbaceous plants in the grove are *Aster concola*, *Vernonia angustifolia*, *Lespedeza repens*, *Dolicholus erecta*, *Crotalaria Purshii*, *Lespedeza virginica*, *Lespedeza Nuttalii*, *Galactia volubilis*, *Stylosanthes riparia*, *Zornia bracteata*, *Baptisia tinctoria*, *Schrankia angustata*, *Polygala grandiflora*, *Euphorbia Curtisii*, *Dasystoma pedicularia* (fly poison), *Helianthemum majus*, *Lechea villosa*, *Lechea racemulosa*, *Lechea Torreyi*, *Chimaphila maculata*, *Hypoxis hirsuta*, *Erigeron ramosus*, *Hieracium venosum*, *Solidago odora*, *Vernonia angustifolia*, *Chrysopis graminifolia*, and *Sericocarpus bifoliatus*. On a ditch bank through an open field near here are a good lot of honey locust trees (*Gleditsia triacanthus*), a few hackberries (*Celtis crassifolia*), and a single small ash tree (*Fraxinus Darlingtoniana*), the only one I have found in the neighborhood of Hartsville.

For the typical low flatwoods I shall select for description that area lying directly south of the residence of Mr. J. E. Miller. Here the long-leaf pine is still present in considerable quantity in mixture with the old-field pine, which is the dominant tree of the flatwoods. The relative abundance of these two pines fluctuates very rapidly according to the slight dips and elevations of the surface, the long-leaf pine preferring the higher ground.

Originally the pines stood pretty close in the flatwoods, but in most places they have been so culled as to be now considerably scattered. The general effect is rather open. The willow oak is abundant, and is perhaps the most characteristic tree. The other arborescent growth consists of water oak, Spanish oak, black jack oak, post oak (a little), black gum, sweet gum, and persimmon. Beneath the trees the shrubbery is more or less clumped, with open spaces between. The small gallberry (*Ilex glabra*) and the wax myrtle (*Myrica cerifera*) are the most abundant shrubs. The former is evergreen and in such open positions is rarely over three feet in height. On May 24th, 1909, it was in full bloom and its black berries of the preceding season were still hanging on in abundance. The wax myrtle is of two forms, a large shrub three or four feet high, that often stands close against the boles of the pines, and a small dwarf variety, one foot high or less, that runs extensively in open places. To this latter form Dr. J. K. Small has given the name of *Myrica pumila*. As there has been some doubt as to whether *M. pumila* is a species or merely a growth form of *M. cerifera* dependent on environmental influences, I undertook to settle the point by planting the two forms side by side both at Hartsville and at Chapel Hill, N. C. After several years each retains its character completely, thus proving at least a varietal distinction.

There is a good deal of the little stagger bush (*Lyonia mariana*) around the edges of the other shrubbery. It is very pretty when covered with its large, white, bell-shaped flowers. The only other shrubs noticed in this area were high blackberries (*Rubus Andrewsianus*) and sumach (*Rhus copalina*). Plate IX is a photograph of these woods.

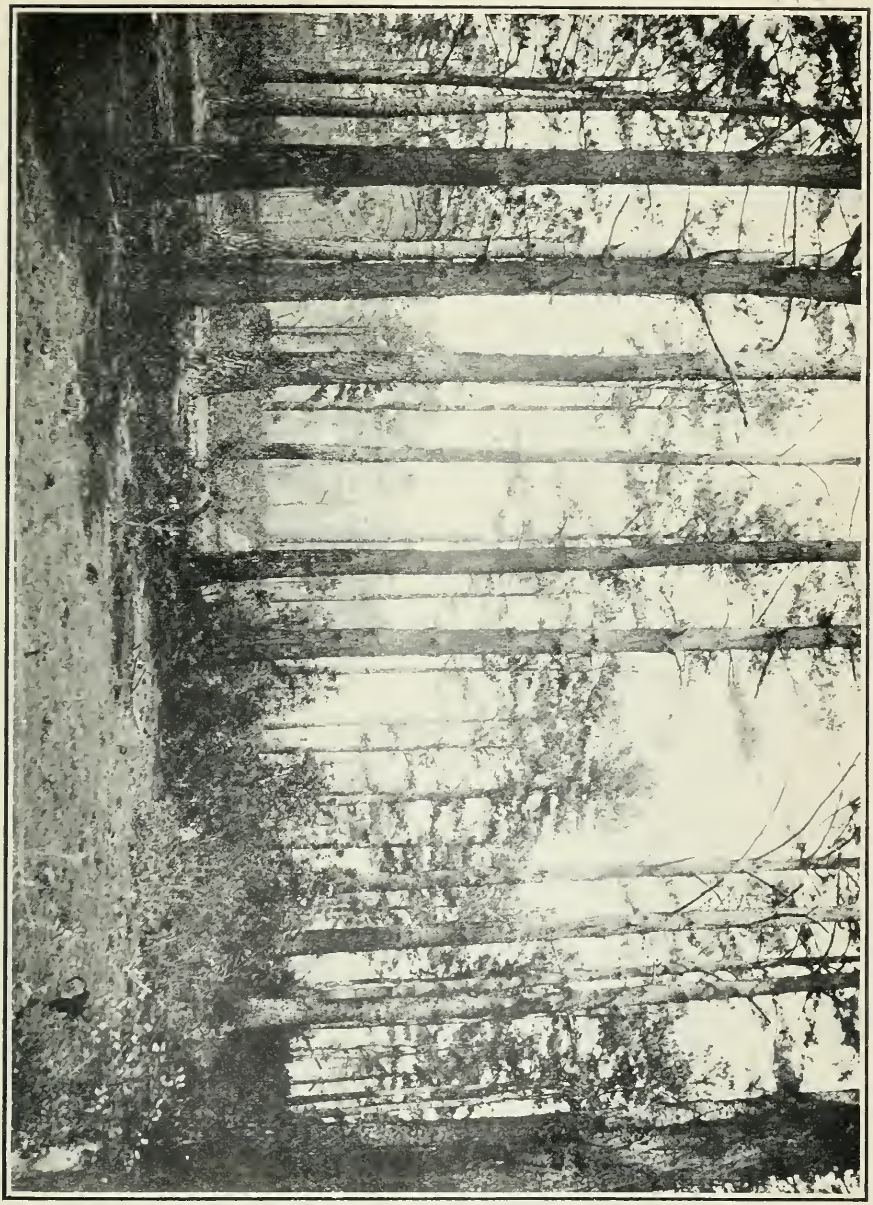
As we pass through these flat woods in a southerly direction the surface gradually becomes more depressed and the soil damper until we enter a typical flatwoods bay, called a "pocosin" in North Carolina.* Its vicinity is marked by an increase in the number of gall-berry and wax myrtle bushes, and the appearance of *Azalea nudiflora* and clumps of catbrier (*Smilax rotundifolia*). In general aspect the flatwoods bay is much like the alluvial bay, but the tiers of vegetation are generally more sharply marked, there being fewer broad leaved trees of medium height to fill in between the pines and the shrubs. But there is considerable variation in this respect. So far as I know there are no bays around Hartsville where the growth is confined to the tall pines and a dense low undergrowth of mostly

*There is some difference of opinion as to exactly what a pocosin is. See Harper in Bull. Torrey Botanical Club, Vol. 34, page 361. 1907.

evergreen shrubs such as I have seen farther down the State near Lane's. The pines in our flatwoods bays are always old-field instead of pond pine, but with the exceptions mentioned below the appearance and constitution of the shrubby undergrowth is almost the same as in the alluvial bays. In addition to the pine the following trees, mentioned in order of abundance, are always present: black gum, sweet gum, red maple, sweet bay, and a little holly (*Ilex opaca*). Among the shrubs the two gall-berries (*Ilex glabra* and *Ilex lucida*) are by far the most plentiful, and next to these in quantity come the high-bush huckleberry (*Vaccinium corymbosus*) and cat-brier (*Smilax rotundifolia*). Choke-berry (*Aronia arbutifolia*) is also present in moderate amount and there is some bamboo-briar (*Smilax laurifolia*), though it is nothing like so plentiful here as in the alluvial bays. Blackberry (*Rubus Andrewsiana*) occurs on the ditch banks, but not in the body of the bay. *Zenobia pulverulenta* and *Zenobia cassinifolia* are two beautiful shrubs of the heath family that are partial to the flatwoods bays, but they are very erratic in their occurrence. They prefer the wet, undrained soil of these bays and are rarely found in alluvial bays,* but all flat woods bays do not contain them. They multiply by underground shoots and frequently from rather extensive patches, to the exclusion of other growth. In Plate X is shown a large clump of each of these species. *Zenobia pulverulenta* is at the right and *Zenobia cassinifolia* is at the left. Both are in flower, and a charming display they make. The point where this photograph was taken is not in the area just described, but in a somewhat similar flat across Black Creek about half mile below the paper mill. In the photograph there is shown some *Lyonia nitida* under the front edge of the large bushes, a slender plant of *Ilex lucida* projecting through the center of the right hand clump and *Ilex glabra* standing behind and to the left. In the immediate neighborhood were *Cyrilla racemiflora*, *Viburnum nudum*, *Aronia arbutifolia*, and small trees of pond pine, red bay, black gum, red maple, and sweet bay.

A comparison of the flatwoods bay or "Pocosin" and the alluvial or well drained bay will show the presence in the latter and

*See, however, page 195 for reference to their occurrence in alluvial bays.



Flatwoods showing Old-field Pines and a few Long-leaf Pines; undergrowth of Candle-berry (Myrica cerifera) and Gall-berry (Ilex glabra).

absence in the former of bamboo-brier (*Smilax laurifolia*), juniper (*Chamacyparis thyoides*), loblolly bay (*Gordonia lasianthus*), swamp azalea (*Azalea viscosa*), swamp wax myrtle (*Myrica carolinensis*). On the other hand the two *Zenobias* and cat-briar (*Smilax rotundifolia*) are found in the flatwoods, but are absent from the alluvial bay. There is the further difference in the Hartsville area of the dominance of the pond pine in the drained bay and of the loblolly pine in the flatwoods bay.

In the bay north-east of the old Lucas place through which the road passes there may be seen a beautiful example of transition from bay to savanna conditions. On the south side of the road near the center of this area the vegetation of the bay circles about and encloses a pretty little savanna of about a quarter acre in extent, where four or five cypress trees are standing on a grassy floor. This sudden change from the bay vegetation is due to a depression in the surface and an increase in the dampness of the soil in consequence.

## The Savannas.

There are all gradations between the level flatwoods and the savanna formations, and there are savannas of every size from an acre or less to a number of square miles.

The savanna is a wet, undrained prairie or meadow with a scattered open cover of cypress and pond pine trees. There is practically no shrubby growth. In late spring and summer these savannas show the most conspicuous display of attractive flowers of any of our plant societies. In May and June the two species of swamp iris or blue flag *Iris versicola* and *Iris prismatica* are conspicuous and beautiful with flowers showing all shades of color from deep blue and lilac to light blue.

The most extensive savanna in Darlington County is the Big Savanna, east of Auburn, about six miles from Hartsville. The Atlantic Coast Line road runs directly across it. I have not had an opportunity to study this particular savanna, but from the train it seems to have the same sort of vegetation as the others I am more familiar with. However, on account of its large size, it is quite probable that it will show some peculiarities on closer acquaintance and I hope some day to make it a more extended visit. The savanna most studied was the one on the back part of Major J. L. Coker's plantation, called "Plantation Savanna" in the herbarium labels. It is a small one, only about three acres in extent, and recent drainage has begun to change it a little. There is here, in addition to the cypress and pond pine, some black gum and sweet gum. The herbaceous cover is made up largely of grasses and sedges. *Juncus aristulatus* and *Rynchospora glomerata* when in fruit give a decided reddish color to considerable areas.

Among the most noticeable flowers of the savanna are *Pluchea bifrons*, *Ludwigia capitata*, *Stachys hyssopfolia*, *Polygala mariana*, *Polygala ramosa*, *Ludwigia hirtella*, *Eupatorium Mohrii*, *Diodia virginiana*, *Gerardia linifolia*, *Rhexia lanceolata*, *Rhexia mariana*, *Linum medium*, *Sabatia lanceolata*, *Oxypolis filiformis*, *Linaria canadensis*, *Dasystoma flava*, *Gratiola pilosa*, *Eupatorium semiserratum*, *Hypericum virgatum*, and *Boltonia asteroides*. In the flatwoods not far from here was found a little *Baccharis halimifolia*. It also occurs sparingly near Prestwood's Lake and the paper mill and seems to be getting more plentiful.

Just to the north of the dam at the paper mill are some low flats, that show almost the same herbaceous growth as a typical savanna. In the wettest spots grow *Typha latifolia*, a few trees of *Salix nigra*, the decorative *Scirpus Eriophorum*, *Juncus scirpoides*, *Juncus trigonocarpus* and *Mikania scandens*. Mingling with these and running out into slightly dryer places were *Rynchospora glomerata*, *Juncus aristulatus* (these two giving a red effect to the meadow with their fruits), *Fuirena squarosa* (very abundant), *Boemerea scabra*, *Hypericum virginicum*, *Eriocaulon decangulare*, *Lachnocaulon anceps*, *Limodorum tuberosum*, *Rhexia mariana*, *Linum medium*, *Linum striatum*, and *Eupatorium rotundifolium*. The somewhat less wet portions of the flats were covered with the following: *Cynoctonum sessilifolium*, *Gratiola pilosa*, *Buchnera elongata*, *Aletris farinosa*, *Spiranthes praecox*, *Hypericum setosum*, *Lobelia Nuttalii*, *Ludwigia hirtella*, *Burmannia capitata*, and *Rhexia lanceolata*. With these flourished large quantities of *Lycopodium adpressum*, and *Lycopodium alopecuroides*, and in the firmer, more sandy spots *Lycopodium carolinianum*. In the dryer parts were

Zenobia pulverulenta and Zenobia cassinifolia in flower.

*Chrysopsis graminifolia*, *Crotalaria rotundifolia*, *Gnaphalium purpureum*, *Rumex hastatulus*, *Psoralea pedunculata*, *Asclepias amplexicaule* and *Hypericum gentianoides*. On a ditch bank through this flat grew a good quantity of *Amelanchier Botraypium*, here not over two feet in height.

## THE BAYS AND SWAMPS.

As the typical "Bay" of this section we may select the one called Burnt Bay, which runs along the southern side of Black Creek valley west of the novelty mill. It is covered with a dense growth of trees and shrubs of which so many are evergreen as to give a general effect of verdure at all seasons. On the edges there is old-field pine and a little long-leaf pine, but the typical pine of the bay, and the only one that extends through most of the deeper parts, is the pond pine. This grows much larger here than in the savannas, reaching a height of over seventy-five feet and a diameter of two and a half feet.

On the edges of the bay there is an attractive fringe of low shrubs that leads up gradually to the taller growth behind. Among these the two gall-berries (*Ilex glabra* and *Ilex lucida*) and the fetter bush (*Lyonia nitida*) are evergreen and so numerous are they proportionally as to give their hopeful winter color to the whole border. Abundant among these are the following deciduous shrubs: swamp azalea (*Azalea viscosa*), *Lyonia ligustrina* var. *foliosiflora*, sweet pepper bush (*Clethra alnifolia*), he-huckleberry or myrtle (*Cyrilla racemiflora*), Virginia willow (*Itea virginica*), swamp sumach (*Rhus Vernix*), swamp waxberry (*Myrica caroliniana*), the two 'possum haws (*Viburnum nudum* and *Viburnum cassinoides*), choke-berry (*Aronia arbutifolia*), the two high bush huckleberries (*Vaccinium fuscatum*, tall, berries black, and *Vaccinium corybosum*, tall, berries blue), high blackberry (*Rubus Andrewsiana*), and a little of the shad bush (*Amelanchier Botryapium*), called "wild currant" here. Yellow jessamine (*Gelsemium sempervirens*), climbs over this border in abundance, and just just behind it are great masses of the bamboo brier (*Smilax laurifolia*), one of the most beautiful evergreen vines in the world. Poison ivy (*Rhus Toxicodendron*), Virginia creeper (*Psedera quin-

*quefolia*), and cross vine (*Bignonia capreolata*) extend throughout the bay, but the bullace (*Vitis rotundifolia*) is confined to the borders.

Next to the pine the largest trees of the bay are black gum (*Nyssa sylvatica*), juniper (*Chamaecyparis thyoides*) and red maple (*Acer carolinianum*). Water oak (*Quercus nigra*) is plentiful in the borders and shallower parts, and Willow oak (*Quercus Phellos*), while not a typical bay tree, is found in Burnt Bay where it edges off into the low sandy woods on the south side.

The most common evergreen trees of the bay are sweet bay (*Magnolia glauca*) and red bay (*Persea pubescens*). They are both extremely abundant and characteristic. The sweet bay is not entirely evergreen with us. There are specimens in Burnt Bay that reach the unusual height of 35 feet. The loblolly bay (*Gordonia lasianthus*) is not nearly so common as the two preceding, but is found scattered near the edges of nearly all bays. It is quite evergreen, and when covered with its fine white flowers it is one of our handsomest trees. Around the edges of Burnt Bay cinnamon fern (*Osmunda cinnamomea*) is plentiful, and there is a little bracken fern (*Pteris aquilina*) and royal fern (*Osmunda regalis*). In the deeper and more shady inner parts are scattered beds of chain fern (*Woodwardia areolata*), and in shallow standing water or mud is the large, coarse "poor man's soap" (*Woodwardia virginica*).

In the low damp woods along the north side of the bay grow old-field pine (*Pinus Taeda*), long-leaf pine (*Pinus palustris*), white hickory (*Carya alba*), dogwood (*Cornus florida*), sassafras (*Sassafras variifolium*), Spanish oak (*Quercus falcata*), willow oak (*Quercus Phellos*), water oak (*Quercus nigra*), and the following shrubs: sparkleberry (*Vaccinium arboreum*), *Vaccinium tenellum*, *Gaylussacia frondosa*, *Myrica cerifera*, *Lyonia mariana*, *Ascyrum stans*, and *Ascyrum hypericoides*. The pretty herbaceous vine called carrion-flower (*Smilax herbacea*) and the wild yam (*Disoscorea villosa*) are to be found in these woods. In an open damp meadow here (savanna conditions) was found *Juncus abortivus* for the first time in South Carolina. With it were *Rhexia virginica*, *Gratiola pilosa*, *Gratiola virginiana*, *Bacopa acuminata*, *Ludwigia linearis*, *Xyris caroliniana*, and *Lobelia Nuttalii*.

The edges of Burnt Bay are in most places either too abrupt or too shady to admit of the best development of many of the attractive flowers that are often associated with bay conditions, although most of them may be sparingly found at places around its margin. For the study of such flowers it is best to cross over Prestwood's Lake to edges of the bays surrounding the savanna-like open area in Captain Cannon's sheep pasture (referred to in the list as "Sheep Pasture Savanna"). The meadow-like area of a couple of acres is low, moist, and sandy, but too well drained to show typical savanna vegetation. It is bounded on both sides by low bays and the transition between the bays and meadow show some interesting plants. Through the open area are scattered a few large trees of the pond pine (*Pinus serotina*) and long-leaf pine (*Pinus palustris*), which is the only aborescent growth except a few small plants of black-jack oak (*Quercus marylandica*), upland willow oak (*Qnercus cinerea*), Spanish oak (*Quercus falcata*), and post oak (*Quercus stellata*). The open space was also dotted with scattered clumps of *Myrica pumila*, *Ilex glabra*, *Alnus rugosa*, *Vaccinium frondosum*, *Lyonia mariana*, *Lyonia ligustrina* var. *foliosiflora*, and *Clethra alnifolia*. Along the wetter edges of the bays the following shrubs made a dense and attractive border: *Zenobia pulverulenta*, *Zenobia cassinifolia* (a little), *Kalmia cuneata*,* *Vaccinium australe*, *Leucothoe racemosa*, *Leucothoe axillaris* (a rare and interesting evergreen), *Azalea vicosa*, *Ilex glabra*, *Ilex lucida*, *Aronia arbutifolia*, *Myrica cerifera*, *Myrica caroliniana*, *Lyonia ligustrina* var. *foliosiflora*, *Fothergilla carolina*, and *Lyonia nitida*. Just back of these the taller bay vegetation began with *Viburnum*

*This interesting little Kalmia seems to be represented in American herbaria only from southeastern North Carolina, and it is generally considered as confined to that State; but Mr. R. M. Harper has called my attention to the fact that F. A. Michaux (in his Journal for July 18, 1794), and Thomas Nuttall (in his "Genera of North America Plants," Vol. I, page 268, 1818) both mention its occurrence at Camden, S. C. See my "Additions to the Flora of the Carolinas. II." TORREYA, Vol. II, page 9, January, 1911.

*nudum*, *Viburnum cassinoides* and *Magnolia glauca* conspicuous on the border. The trees of the bays were red bay (*Persea pubescens*), black gum (*Nyssa sylvatica*), Carolina red maple (*Acer carolinianum*), and pond pine (*Pinus serotina*), and a little juniper (*Chamaecyparis thyoides*). Bamboo briar (*Smilax laurifolia*) and red-berried bamboo (*S. Walteri*) were plentiful. Partially submerged in an open piece of water in the bay were found *Juncus repens* and *Eleocharis Torreyana*.

In certain places on the east side the shrubby borders were replaced by a wet Sphagnum bog in which were masses of cinnamon fern (*Osmunda cinnamomea*) and fine conspicuous clumps of pitcher plants (*Sarracenia flava*). *Sarracenia purpurea* is also plentiful here in the Sphagnum, and *S. rubra* grows abundantly where the Sphagnum is less deep. Along this border five species of Orchids were found,—*Pogonia ophioglossoides* and *P. divaricata* (blooming on May 24th), *Limodroum graminifolium* (July 8),* *Habenaria blephariglottis* and *Habenaria cilaris* (August 20th). In July *Rhexia mariana*, *R. lanceolata*, *R. ciliosa*, and *R. glabella* make a very bright effect with their handsome flowers, while in May the white flowered *Zyadenus angustifolius* and *Chamaelirium luteum* were conspicuous in the same place.

In the main body of the savanna where the soil was moist but not boggy grew *Rynchospora glomerata*, *Juncus aristulatus*, *J. trigonocarpus*, *Lacnocaulon anceps* (small "hat pin"), *Buchnera elongata*, *Marshallia obovata*, *Bartonia lanceolata*, *Tofieldia glabra* (blooming about Sept. 1st), *Xyris arenicola*, *Aletris farinosa* [a yellow Alestris, supposed to be *Aletris aurea*, was collected but lost], *Spiranthes praecox*, *Polygala lutea*, *Linum medium*, *Eupatorium rotundifolium*, *Eupatorium verbenaefolium*, *Ascyrum stans*, and *Aster squarrosus* (not seen in bloom). Towards the outer edge of the savanna where the soil was dryer grew *Seriocarpus asteroides* (said by Small to grow in rocky woods), *Lespedeza repens*, *Indigophora*

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**Limodorum tuberrosum* also will no doubt be found here, but I did not happen to see it. It is rather plentiful in such situations in our region. A white flowered form of the species was found on the edge of another bay not far from this spot and we have seen it since in several places.

Upper part of Prestwood's Lake showing large dead Cypress trees.

*caroliniana*, *Vaccinium tenellum*, *Gaylussacia dumosa*, and *Lyonia mariana*. Farther up still, in the flat sandy pasture, *Stipulicida setacea* was collected.

### THE DEEPER SWAMPS.

We have at Hartsville no swamps of the type found by the larger muddy rivers that are subject to frequent floods, as the Pee Dee and Santee, and many plants that affect such swamps are absent at Hartsville. Such, for example, are overcup oak (*Quercus lyrata*), elm (*Ulmus alata* and *Ulmus americana*), water hickory (*Carya aquatica*), tupelo gum (*Nyssa aquatica*), swamp chestnut oak (*Quercus Michauxii*), planer tree (*Planera aquatica*), and deciduous holly (*Ilex decidua*).

Our swamps and bays grade insensibly into each other, and the edges of all our swamps are bays. The typical bay would have a scattering cover of large trees with a dense tangle of undergrowth of shrubs and vines, largely evergreen. The typical swamp has a heavy cover of large trees (among which is always cypress) and a more or less open floor beneath. However, there are to be found on the tussocks and tree bases in the swamps nearly all the shrubs that have been described as making up the marginal growth of Burnt Bay.

As a good example of the typical creek swamp I shall choose that part of Black Creek swamp lying just behind the old Bacot Place. Here the tall, flat-crowned cypress trees reach high above all else, and give an impressive dignity to the place Reaching nearly to their lower branches are fine specimens of black gum and tulip tree, and beneath these are smaller trees of red maple, juniper and sweet bay.

The undergrowth, which is rather dense, consists of fetter bush (*Lyonia nitida*), Virginia willow (*Itea virginica*), large gall-berry (*Ilex lucida*), a little of the small gall-berry (*Ilex glabra*), both 'possum haws (*Viburnum nudum* and *Viburnum cassinoides*), swamp azalea (*Azalea vicosa*), poison sumach (*Rhus Vernix*), male berry (*Lyonia ligustrina* var. *foliosiflora*), high blackberry (*Rubus Andrewsianus*), and Alder (*Alnus rugosa*). It was a little surprising to find here on the highest tussocks a little holly (*Ilex opaca*), myrtle (*Cyrilla racemiflora*) and French mulberry (*Callicarpa americana*). The two last are at their best in a sunny exposure, and are not noticeable constituents of swamps. *Mikania scandens* clambered about among the shrubs, and cross vine (*Bignonia capreolata*) and poison ivy (*Rhus Toxicodendron*) ascended high into the trees.

In the shallow water or saturated soil there was a considerable herbaceous growth of marsh St. John's-wort (*Hypericum virginicum*), lizard's tail (*Saururus cernuus*), joe-pye weed (*Eupatorium maculatum*), *Mayaca Aubletii*, some cinnamon fern (*Osmunda cinnamomea*), and chain fern (*Woodwardia areolata*) in abundance. Near the large spring on the edge of the swamp at this place were lady fern (*Asplenium Filix-femina*), and several plants of the grape fern (*Botrychium virginianum*), which were the only specimens of this interesting species that I have found in Hartsville.

Three of the most attractive and interesting of our swamp plants were not noted in the immediate spot just described, but all three of them are conspicuous in that bit of swamp lying between the dam and the creek crossing at the paper mill. They are wild wistaria (*Wistaria frutescens*), Walter's smilax or red-berried bamboo (*Smilax Walteri*) and Storax (*Styrax americana*). The wistaria is very like the Chinese one that, in two shades —purple and white—is grown for ornament. It blooms about three weeks later than the Chinese, and its flowers are borne in smaller clusters and are deeper colored than in that species. Our vine is offered for sale by nurserymen and there is an improved form (variety *magnifica*) that is more floriferous in cultivation than the wild plant.

Walter's smilax climbs up as high as twelve feet or more into the trees, and in winter it makes a beautiful show with its bright scarlet berries. It was named for one of the best known early botanists of America, Thomas Walter, of South Carolina.

The storax generally grows along the creek margins or other open spots where it can get some sunlight. It is a good sized bush that bears a profusion of pretty bell-shaped white flowers in mid-

Dead Cypress tree in Prestwood's Lake with a collar of shrubs.

dle April. It, too, is sold by dealers and is well worthy of cultivation.

The tall cane (*Arundinara macrocarpa*) grows plentifully in the deep, rich soil of swamps, preferring the better lighted edges of the streams, and the dwarf cane (*Arundinaria tecta*) is abundant on the edges of bays and ponds. I have never known either species to fruit at Hartsville, though they probably do so at long intervals.

In the open swampy places below the dam there is in July a handsome display of the white flowers of *Sabatia lanceolata* and the greenish yellow flat-topped cymes of *Polygala cymosa*. Earlier in the season the small white flowers of the swamp fleabane (*Erigeron vernus*) are numerous enough to be quite conspicuous.

## THE LAKES AND PONDS.

In many respects the margins of the more extensive bodies of water duplicate certain of the conditions already described, but it is not so at all points, and it is best to include the marginal growth in any discussion of their vegetation. I shall first consider the flora of

### PRESTWOOD'S LAKE.

This artificial lake was formed by the damming of Black Creek by the Carolina Fiber Company about eighteen years ago. The lake itself may be said to extend for a little over a mile, but there is back water in the creek run for nearly a mile and a half. The width of the lake is about a quarter of a mile across at its broadest part.

When the swamp was cleared in preparation for the lake it was decided as an experiment to leave several very large cypress trees in the deeper part near the dam and test the effect of the altered conditions. Standing in about twelve feet of water they continued to live for three or four years, but got weaker all the time and at last gave up the struggle. In the upper end of the lake a considerable section of the swamp was left uncut, and although the depth there is only about five or six feet, the results have been the same so far as the larger trees are concerned. The small cypress trees have for some reason shown greater adaptability.

and many of them are left in apparrently good health. They grow very slowly but bear fruit abundantly. The only plants of the original growth that have remained alive with their roots under five feet or more of water are cypress, red maple (*Aver carolinianum*), myrtle (*Cyrilla recemiflora*), storax (*Styrax americana*), bamboo briar (*Smilax laurifolia*), and Walters' smilax (*Smilax Walteri*).

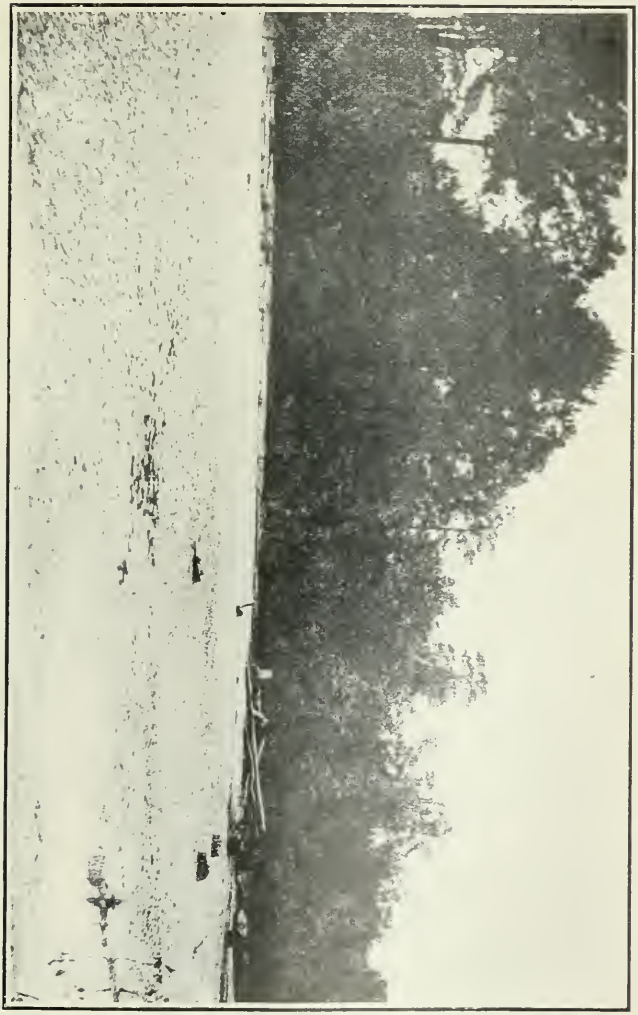
In Plate XI is shown this part of the lake. The large dead cypresses are seen in the background, and a number of small live ones are seen in the front. In the middle foreground is a large bush of alder (*Alnus ruyosa*), growing on a stump. The mossy-looking growth hanging from the tops of some of the dead trees in the lichen *Usnea barbata*.

The stumps, floating logs and standing dead trees support a large population of shrubs and herbs. The dead cypress shown in Plate XII has a dense collar of shrubs and young trees surrounding it at water level. Here are growing Carolina red maple (*Acer carolinianum*), juniper (*Chamaecyparis thyoides*), fetter bush (*Lyonia nitida*), myrtle (*Cyrilla racemiflora*), sweet pepper bush (*Clethra alnifolia*), *Zenobia pulverulenta* and *Lyonia ligustrina var. foliosiflora*. These plants were all rooted to the decaying bark of the cypress, five and a half feet above the lake bottom.

Some of the floating logs carry such a profusion of gay flowers as to look like miniature gardens. On one of these I have noted the following: juniper (*Chamaecyparis thyoides*), Carolina red maple (*Acer carolinianum*), alder (*Alnus rugosa*), fetter bush (*Lyonia nitida*), *Zenobia pulverulenta*, *Leucothoe racemosa*, myrtle (*Cyrilla racemiflora*), *Hypericum verginicum*, *Hypericum canadense*, sundew (*Drosera intermedia*), *Utricularia juncae*, *Xyrus caroliniana*, and species of *Rynchospora*.

The aquatic plants of the lake are: *Brasenia Schreberi* (water shield), *Nymphoides aquaticum* (floating heart), *Potamogeton diversifolius*, *Potamogeton heterophyllus*, *Nymphaea advena* (yellow pond lily), *Utricularia fibrosa* (bladderwort), *Utricularia biflora* (bladderwort), and *Mayaca fluviatilis*.

The Mayaca is new to South Carolina, not having been reported before north of the Gulf States. It is a very delicate plant,



A dense colony of Water Shield (Brasenia Schreberi) covering the water on the south side of Prestwood's Lake.

growing in considerable masses, entirely submerged in rather shallow water* The yellow pond lily has made an entrance in the last few years. About four years ago I noticed one plant at about the spot shown in Plate XI. Now there are a dozen or more colonies in that part of the lake.

Water shield is now the most conspicuous aquatic plant of the lake. Its small floating leaves coated on the under side with a beautiful clear jelly cover the water in large areas near the edges. A dense colony of it is shown in Plate XIII.

*Nymphoides aquaticum* (*Limnanthemum*), with large floating leaves that look much like those of the water lily, is not abundant: in fact, it appears to be much less so than it was several years ago.

It is rather surprising that the water lily (*Castalia odorata*) and the small floating heart (*Nymphoides lacunosum*) have not yet made an entrance into the lake. They are plentiful in Kilgore's Mill Pond, only about a mile away.

Over a considerable area of the lake near the edge behind Captain Cannon's Place the water is only a few inches deep, forming a bog. The swamp had been cleared off here just before the water was raised, but it is now covered with a rather dense second-growth of the following plants: *Taxodium distichum* (cypress), *Salix nigra* (black willow), *Alnus rugosa* (alder), *Cephalanthus occidentalis* (button bush), *Callicarpa americana* (French mulberry), *Viburnum nudum* ('possum haw), *Nyssa sylvatica* (black gum), *Itea virginica* (Virginia willow), *Boemeria scabra*, *Typha latifolia* (cat-tail), *Saururus cernuus* (lizard's tail), and *Peltandra virginica* (moccasin corn). Climbing over the shrubs in great abundance was *Mikania scandens*.

On the muddy shore, not covered with water, there is a good colony of young *Pinus Taeda* (old-field pine). Near them, in addition to most of the above, were *Magnolia glauca*, *Clethra alnifolia* *Cyrilla racemiflora*, *Liquidamber Styraciflua*, *Lyriodendron tulipifera*, *Ilex glabra*, *Rubus Andrewsianus*, *Decodon verticillatus*, and the

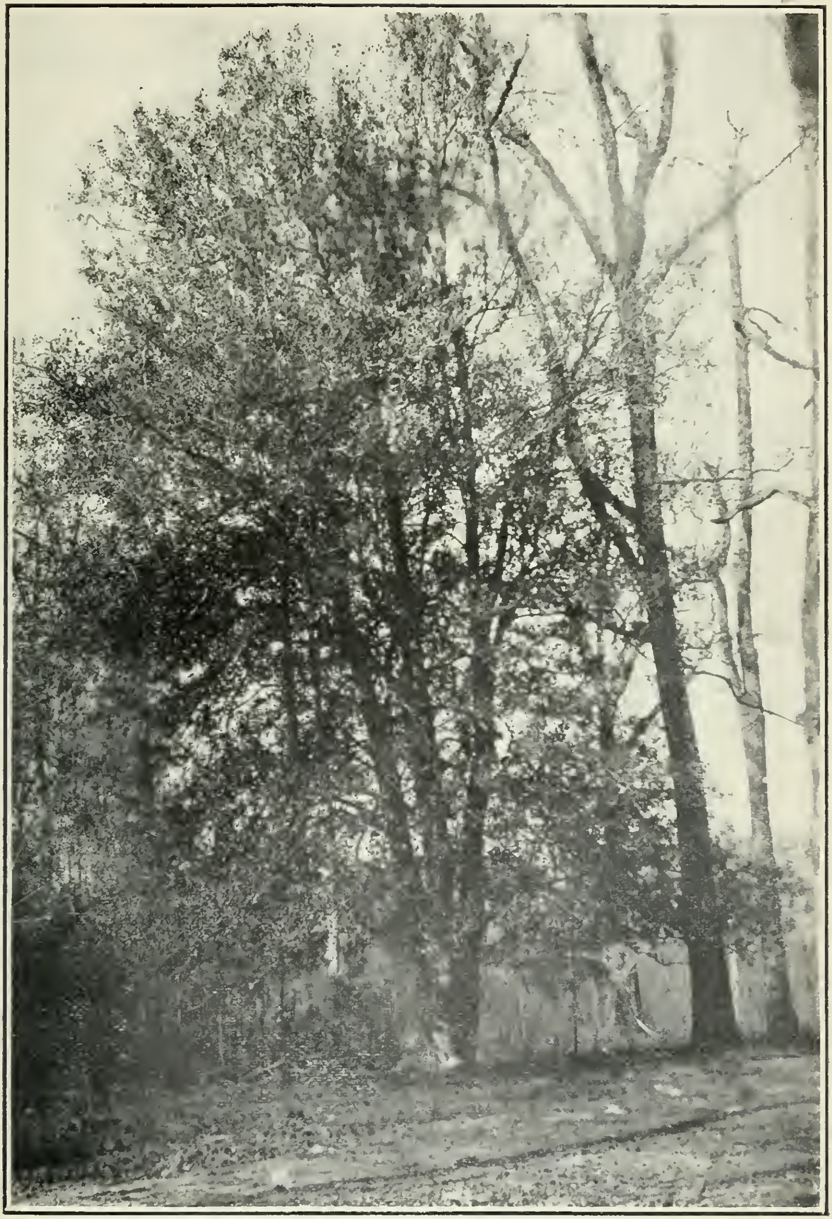
*There is some doubt as to distinctness of *Mayaca fluviatilis*. It may be nothing more than a submerged form of *M. Aubleti*.

ferns *Osmunda cinnamomea* and *Woodwardia areolata.*

Where the border of the lake is a gentle sandy slope, as it is on the south side above Prestwood's Bridge, the first vegetation consists of large patches of the grass *Panicum hemitomum* in shallow water; behind this in shallow water and on the muddy edge is the larger grass *Panicum scabriusculum;* then handsome clumps of the tall yellow-flowered *Xyris fimbriata* and large pipewort, or "hat pins" as we call it (*Eriocaulon decangulare*), with flowers in compact white balls. Mixed with the last two or just behind them are *Iris versicola*, *Iris prismatica*, *Hypericum verginicum* (Elodea), *Proserpinaca pectinata*, *Sclerolepis unifiora* (a pretty little pink-flowered composite), *Utricularia juncea*, *Xyris caroliniana*, *Drosera intermedia*, *Mayaca Aubleti*, *Lycopus pubens*, *Ludwigia linearis*, *Stachys hyssopifolia*, *Rotala ramosior*, and *Polygala lutea*. Here also was discovered a fine colony of the orchid *Hebenarea Nuttalii*, with greenish flowers, a species not before found in the State of South Carolina.

A little behind these as a rule were *Carphephorus bellidifolius*, *Diodia virginiana*, *Ascyrum hypericoides*, *Spiranthes praecox*, *Limodorum tuberosum*, *Rhexia ciliosa*, *Bartonia lanceolata*. The large ferns *Osmunda cinnamomea* and *Woodwardia virginica* were conspicuous here, and the smaller *Woodwardia areolata* and *Lycopodium alopecuroides* were abundant. *Lycopodium adpressum* occupied slightly less wet situations.* Mingled with these herbs were scattered clumps of sweet pepper bush (*Clethra alnifolia*), swamp azalea (*Azalea viscosa*), low gallberry (*Ilex glabra*), fetter bush (*Lyonia nitida*), *Zenobia pulverulenta*, alder (*Alnus rugosa*), button bush (*Cephalanthus occidentalis*), myrtle (*Cyrilla racemiflora*), groundsell tree (*Baccharis halimifolia*) and yellow jessamine (*Gelsemima sempervirens*); also small young trees of cypress (*Taxodium distichum*), Carolina red maple (*Acer carolinianum*), black willow (*Salix nigra*), and juniper (*Chamaecyparis thyoides*). Still farther up where the soil was damp but not soaked, where the white goldenrod (*Solidago* sp.), *Galactia regularis*, meadow beauty (*Rhexia lanceolatat*, nearly white), *Rubus Andrewsianus*, *Vaccinium vaccillans*, *Gaylussacia frondosa*, *Gaylussacia dumosa*, *Rhus copalina*, *Pteris aquilina*, *Vitis rotundifolia* and *Diospyros virginica*.

*See notes by me on these two species of *Lycopodium* in THE FERN BULLETIN, Vol. 17, July, 1910.



A large Holly tree (Ilex opaca) near the lake.

On the upper edge of this society was a large clump of male plants of *Ilex carolinana*. A little farther back a low sandy ridge supported almost the typical growth of the sand hills, with long-leaf pine (*Pinus palustris*), turkey oak (*Quercus Catesbaei*), black-jack oak (*Quercus marylandica*), upland willow oak (*Quercus cinerea*), post oak (*Quercus stellata*), sparkleberry (*Viburnum arboreum*), poison oak (*Rhus quercifolia*), and wire grass (*Aristida stricta*) as the most conspicuous vegetation.

On the more or less wet edges of the lake at other points were collected the following: *Lysimachia terrestris*, *Radbeckia hirta*, *Sabatia brachiata*, *Hypericum fasciculatum* (a good sized heath-like bush), *Bradburia virginica*, *Ludwigia alternifolia*, '*Apios tuberosa* (known as "ground nut" on account of its numerous edible underground tubers), *Jussiaea decurrens*, *Myrica cerifera*, *Wistaria frutescens*, *Carex macrokolea* and *Scirpus Eriophorum*. The last is one of the handsomest herbaceous plants of the lake edge.

Just above the dam on the northern side there is in late summer a conspicuous show of the large white plumes of the very tall grass *Erianthus saccharoides*. I have not noticed golden club (*Orontium aquaticum*) in the lake, but in the run of Crowley's branch just above the old broken dam there is a fine lot of this interesting plant. It is a member of the same family as the calla lily, but has no spathe around its fleshy, yellow spike of flowers. It may be seen at many of the branch crossings in our section. The moccasin corn (*Peltandra virginica*), which is so plentiful in the shallow water of the lake edge, is a member of the same family.

On the low earth dam across the lake from the paper mill was collected *Solidago verna* (spring goldenrod) for the first time in South Carolina.* Other plants collected on this dam were *Smilax glauca*, *Rhynchosia simplicifolia*, *Penstemon laevigatus*, *Apocynum pubescens*, *Lactuca graminifolia*, and *Erigeron ramosus*.

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*See my "Additions to the Flora of the Carolinas," in BULLETIN TORREY BOT. CLUB. Vol. 36, page 635, 1909. I have since found this species to be plentiful in the low woods near the lake. By June 1st of this year (1911) its blooming period was nearly over.

KILGORE'S MILL POND.

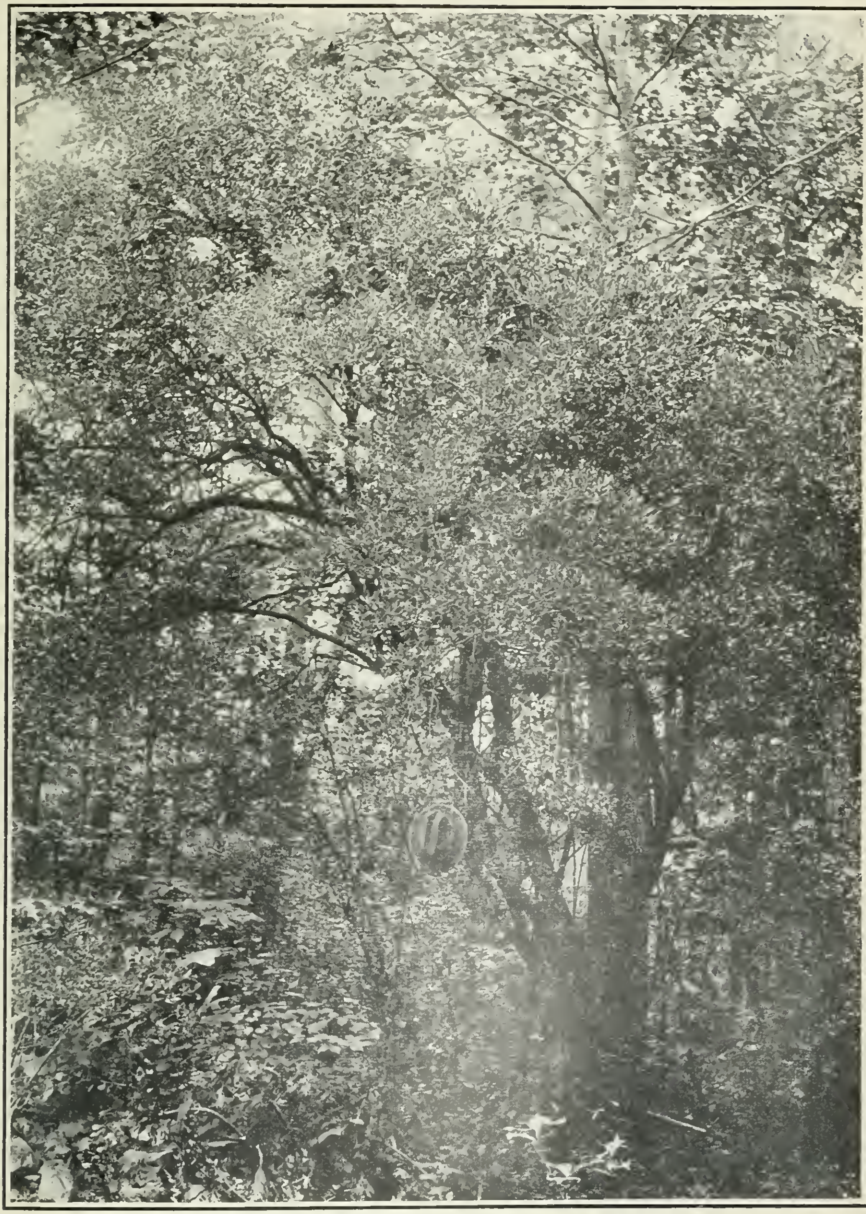
This is a small body of water, much older than Prestwood's Lake, that lies in the low sand hills about one mile northeast from Hartsville. A study of the vegetation and its surroundings resulted in the collection of a considerable number of plants not seen around Prestwood's Lake. *Nymphoides lacunosum*, not found in the lake, was abundant here with *Nymphoides aquaticum*, and submerged in the stream just below the mill race was *Scirpus subterminalis*, not before reported south of New Jersey (but I find a collection of it in the N. Y. Bot. Garden from Mississippi).*

On the west side of the pond is a flat marsh, inundated generally with several inches of water, which is covered almost all over with a pure growth of *Eleocharis melanocarpa*. In deeper spots this is replaced by *Eleocharis quadrangulata*. On the edges of this marsh grew abundantly *Rynchospora glomerata* and *Fuirena squarosa*. *Juncus repens* grew in dense patches in the shallow water, while *Rynchospora corniculata* and *Juncus scirpoides* were scattered on the margins. *Utricularia juncea* also grew sparingly here, but on the other side of the pond it was so plentiful in the shallow water as to give a marked yellow color to the margin. In the same situation on the east side was the little *Eleocharis Torreyana*, partly submerged and mixed with *Mayaca Aubleti* and some *Nymphoides lacunosum*. Behind these was a zone containing clumps of the large, handsome *Xyris fimbriata* mixed with the smaller *Xyris elata* and with *Ascyrum hypericoides*, *Proserpinaca pectinata*, *Schlerolepis uniflora* and some large "hat pins" (*Eriocaulon decangulare*). Back of this zone is a dense growth of the large grass *Pinicum scabriusculum*, with some of the attractive tall sedge *Scirpus Eriophorum*. With these were a few small scattered individuals of *Alnus rugosa*, *Nyssa biflora* and *Acer carolinianum*. In about this situation were found a number of specimens of the greenish white orchid *Habenaria clavellata*, one of the rarest of our plants.

This zone passes beyond into a flat moist bay of poor soil

*See my "Additions to the Flora of the Carolinas," in BULLETIN TORREY BOT. CLUB. Vol 36, pape 635, 1909.

204



A large tree of Sparkleberry (Vaccinium arboreum) near Black Creek

covered with an open growth of stunted trees and shrubs. *Nyssa biflora* and *Acer carolinianum* were the largest growth, and among them were *Alnus rugosa*, *Magnolia glauca*, *Rhus copalina*, *Rhus Vernix*, *Myrica pumila*, *Ilex glabra*, *Ilex lucida*, *Cyrilla racemiflora*, *Lyonia nitida*, *Prunus serotina*, *Viburnum nudum*, *Viburnum cassinoides*, *Rhus Toxicodendron*, *Rubus Andrewsianus*. Scattered here and there were a few small trees of *Pinus palustris*, *Pinus serotina* and *Chamaecyparis thyoides*. It was rather surprising to find in such a place large quantities of broom sedge (*Andropogon virginicus*). The smaller growth was *Pluchae foetida*, *Eupatorium maculatum*, *Eupatorium rotundifolium*, *Rhexia mariana*, *Centella repanda*, *Osmunda cinnamomea*, *Woodwardia areolata* and *Lycopodium alopecuroides*.

In a small wet meadow to the east of the pond were collected *Polygonum hydropiperoides*, *Scutellaria integrifolia*, *Oldenlandia Boscii*, *Bacopa acuminata*, *Viola lanceolata*, *Gratiola pilosa*, *Diodia virginiana*, *Aster cordifolius*, *Linum striatum*, and *Hypericum virgatum*.

Along the wet crossing below the mill *Verbena polystachya* was picked up; and in slightly damp soil near here were *Hieracium Gronovii*, *Kneiffia arenicola*, *Crotalaria rotundifolia* and *Helianthemum majus*.

On the dam grew *Wistaria frutescens*, and in the damp woods on the west side were a number of plants of *Berchemia scandens* (supple jack), a vigorous high-climbing vine, and one of the rarest woody pants of Hartsville. There is a good specimen of it at the Snake Branch crossing, just above the paper mill.*

*This article is the first part of a larger pamplet, containing a systematic list and other information in regard to Hartsville plants, that is soon to be published by the Pee Dee Historical Society, Hartsville, S. C.