

Differentiation of Charred Corn Samples via Processing Methods:
An Ethno-Archaeological and Experimental Approach

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May 12th, 2008

A Senior Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of
Bachelor of Arts in Archaeological Studies
University of Wisconsin-La Crosse

The purpose of this paper is to illustrate the connection between Zea mays, or corn, processing methods and certain physical identifying characteristics that are visible under magnification of charred corn from the archaeological record. Based on ethnographic research of corn processing and cooking methods for extant tribes' in the Mississippi and Missouri River valleys, a series of experiments were conducted to replicate the likely processing methods employed by Oneota peoples that would produce charred corn kernels in order to duplicate what is recovered from the archaeological record. Results were then compared with the charred corn samples from the Pammel Creek (47Lc61) and Valley View (47Lc34) sites, both of which exhibit Oneota occupation and are located along the Upper Mississippi Valley in western Wisconsin. Similarities in physical identifying characteristics, namely corn kernel shape, degree of kernel distortion, and the presence or absence of corn kernel embryos, indicated that parched corn was being processed by boiling at both of these sites.

Introduction

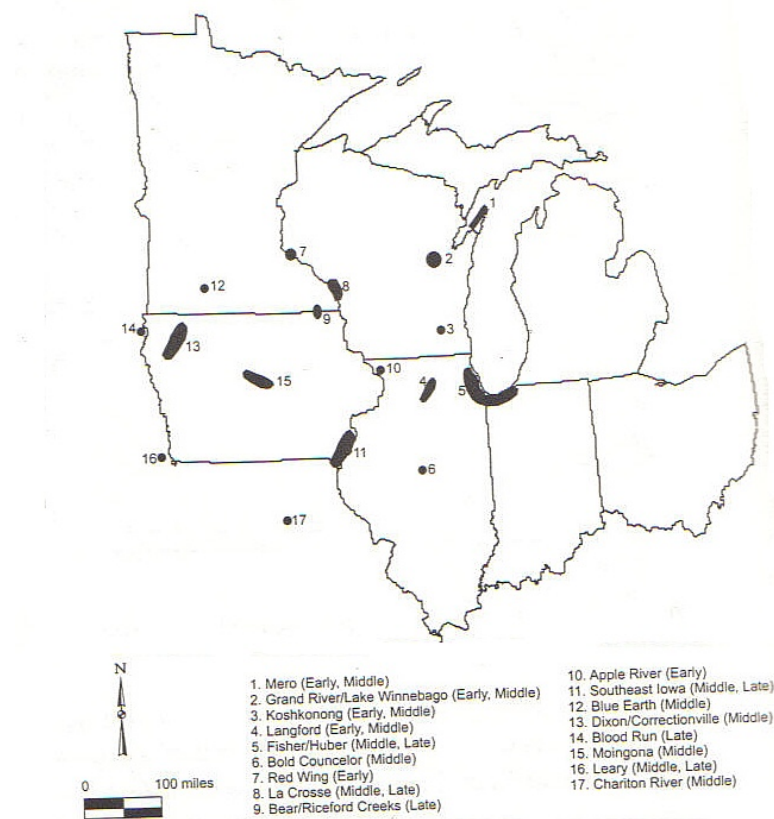
Evidence of subsistence strategies, if present, are an important component for archaeological sites. The resulting interpretation from such evidence can aid not only in the interpretation of site function but also in determining seasonality. Furthermore, such evidence can serve to authenticate cultural or group continuity between geographical locations and the expanse of time. Furthering research in the subsistence strategies of corn agriculture, preparation, and preservation by historic and prehistoric American Indian groups is no exception and has been pursued by many scholars.

Specifically, this paper addresses the many implications that research into the subsistence strategies of corn preparation, or processing, could have for interpretation of the Oneota culture of Midwestern North America. Some of the first detailed subsistence analyses for Oneota archaeological sites included the Vosburg site in Minnesota (Anfinson 1997) and the Valley View site in Wisconsin (Stevenson 1994). Several others have also been conducted since, but fail to address the identification of specific corn preparation methods from interpretation of the charred corn remains (Arzigian 1989, 1994). Much more attention has been paid to the Oneota subsistence strategies of corn agriculture (as is evident from excavated raised agriculture fields) and preservation (inferred from excavated storage pits and experimentation with storage pits). It is my research goal to be able to better understand site function and seasonality through enhancing the knowledge of charred corn remains recovered from Oneota archaeological sites, by determining what, if any, are the physical, qualifying characteristics of charred corn from the archaeological record that specifically indicate any corn processing method(s) (such as boiling corn or hominy production) that were being utilized.

Background

The Oneota culture was fully established from approximately A.D. 1300 until the time of European contact and was the result of Mississippian cultural influence upon Late Woodland groups (Arzigian et al 1994, Henning 1970, Theler and Boszhardt 2003, Tiffany 1998) of the upper Midwest of North America that occupied the areas of the upper Mississippi River Valley and extended from the eastern edge of Lake Michigan into the plains region surrounding the Missouri River Valley (Harvey 1979, Theler and Boszhardt 2003, Tiffany 1979). The extent of Oneota localities can be seen in Figure 1.

Figure 1: Oneota localities throughout time (Theler and Boszhardt 2003).



Oneota village sites were supported in areas along waterways that provided sufficient timber for shelter construction while offering an environment suitable to agriculture, hunting, and gathering subsistence practices (Anfinson 1997, Arzigian 1989, 1994,

Blaine 1979, Harvey 1979, Overstreet 1997, Theler and Boszhardt 2003). Yet, the Oneota also employed regional subsistence strategies that included the exploitation of lake resources in eastern Wisconsin to heavy reliance on buffalo hunting in the plains area (Theler and Boszhardt 2003).

Oneota culture is most notably marked by the homogeneity of its ceramics, which consists of shell-tempered, globular vessels decorated with various trailing design motifs (Anfinson 1997, Boszhardt 1989, Harvey 1979, Henning 1970, Mott Wedel 1959).

Another shared cultural characteristic is the presence of agricultural village or hamlet sites with “bowl-shaped to bell-shaped” cache or trash pits (Harvey 1979:42). Lithic technology consisted of triangular un-notched projectile points with concave and convex bases, un-notched end scrapers, knives, manos, and mauls (Anfinson 1979, Boszhardt 1994, Harvey 1979, McKern 1945, Mott Wedel 1959, Rodell 1989, Tiffany 1979). The most common worked bone artifacts found at Oneota sites are bison scapula hoes (Harvey 1979, Tiffany 1979, Theler and Boszhardt 2003). Oneota burials consisted of individual graves in village cemeteries with elaborate burials for primarily reserved for males or children (Arzigian et al. 1994, Harvey 1979).

Yet distinctive local variation exists across Oneota culture. Examples of such variation include shelter types (which vary from rectangular or circular wooden houses to square, rectangular, or circular earth lodges) (Harvey 1979), expression of design on ceramic vessels (Harvey 1979), and lithic raw material sources (which are often dominated by a local raw material yet also include some exotic raw materials) (Anfinson 1997, Rodell 1989). Therefore, Overstreet (1997) and Theler and Boszhardt (2003) explain that the Oneota culture is understood in terms of local phases, such as the Brice

Prarie, Pammel Creek, and Valley View Phases of the La Crosse, Wisconsin locality, within the context of the Early/Emergent (A.D. 1150 to A.D. 1350), the Middle/Developmental (A.D. 1350 to A.D. 1500), or the Late/Classic (A.D. 1500 to A.D. 1700) horizons.

Methodology

When considering my methodological approach, I have taken a theoretical position that is shared by Skibo, which is a combination of an ethno-archaeological approach and experimental archaeology can assist in realizing the greatest potential for understanding archaeological problems and "...[develop] material-behavioral correlates that are more readily applied in archaeological inference (Skibo 1992)." In order to facilitate this combination methodology, also encouraged by Chang (1958), Ascher (1961), and Binford (1968), I employed both field and laboratory experiments that were heavily based on ethnographic research. Said research focused on the preservation and preparation of corn, corn harvesting practices, corn parching and storing practices, along with common or seasonal recipes that are used by extant American Indian tribes in the Mississippi and Missouri River Valleys that have a shared cultural or linguistic heritage or practice similar agricultural techniques with the Oneota.

Ethnographic Literature Review

It was important for me to locate relevant ethnographic data concerning corn processing and cooking techniques of extant tribes' with an ancestral connection or at least a close life way connection with the Oneota people. Blaine (1979) contends that the

Oneota people "...lived in culturally similar communities scattered over a contiguous area in the Mississippi and Missouri river valleys [that included] the present states of Iowa, Wisconsin, Minnesota, Missouri, Kansas, and Nebraska" and he and others contend that their modern descendants include the Ioway, Otoe, Missouri, Winnebago, Osage, Kansas (Griffin 1937, Mott 1938, Henning 1970, Tiffany 1979), and Quapaw peoples (Blaine 1979). Present day peoples of the Missouri River Valley that share similar agricultural practices to the Oneota include the Dakota, the Mandan and the Hidatsa as were reported to me by Dr. Constance Arzigian via electronic correspondence in 2007 and Dr. Joseph Tiffany via a personal communication in 2008. Additionally, Foster (1999) relates traditional tribal accounts that state the clans of the Ioway ancestors united ages ago to form one people. These clans came from the western prairies, the great lakes, the eastern woodlands, the north, and included the mound builders from along the bluffs of the "great river." These tribal accounts claim that the Ioway, Omaha, Ponca, Kansa, and Osage were once "all one people... when all the land of this middle place was theirs (Foster 1999)." Historical records cited by Richman (1931) that place the Ioway in Iowa or on the western side of the Missouri River before A.D. 1700, including accounts by Perrot and Father Louis Hennepin, lend further credence to the Ioway's oral history.

Professor John Koontz (2003), of the University of Colorado – Boulder, also provides evidence for the shared heritage between the present day Ioway, Otoe, and Missouri tribes due to their belonging to a shared branch of the Souian language group. John P. Staeck (2000) provides evidence based on analyses of oral folklore that the Ho-Chunk (Winnebago) people share similar belief structures with certain Souian-speaking peoples, specifically the Lakota. Staeck (2000) and Tiffany (1979) also demonstrate

archaeological parallels consistent with inferred trends of the prehistoric Ho-Chunk from said folklore that include agricultural villages of varying size and ceramic decoration motifs of Oneota peoples.

Based on this understanding of the peoples closely related to the heritage and life ways of the Oneota, various accounts on the dietary customs and processing methods associated with corn were ascertained. Corn, was preserved for storage by parching and then either ground into flour or meal, threshed and stored as loose kernels, or stored while still on the cobs (Wilson 1981, 1987, Will 2004). The parching itself could be done in various ways while corn was either green (unripe and sweeter in flavor) or ripe. Green corn would have been parched by the Mandan, Hidatsa, Arikaras, and Omaha by parboiling the cob and later picking off the grain from the cob with a clam or mussel shell to allow the corn to dry and harden while on a skin in the sun. Also, the Omaha and Pawnees might have roast the green corn on coal beds while the corn was still in their husks, then remove the grains and dry them on a skin or dry them while the grains were still on the cob (Will 2004). The parching of ripe corn often excluded the process of parboiling or roasting (Wilson 1981, 1987, Will 2004) except for the Pawnees which were said to have sometimes skewered corn cobs on sticks and parch them by holding them over the fire to dry (Will 2004). Otherwise, ripe corn parching required that corn cobs be husked, with the longest cobs braided together by their husks and hung to dry and the shorter cobs laid out on drying stages (elevated wooden platforms) to dry in the wind (Wilson 1987, Will 2004). The drying process took about four days (Wilson 1987).

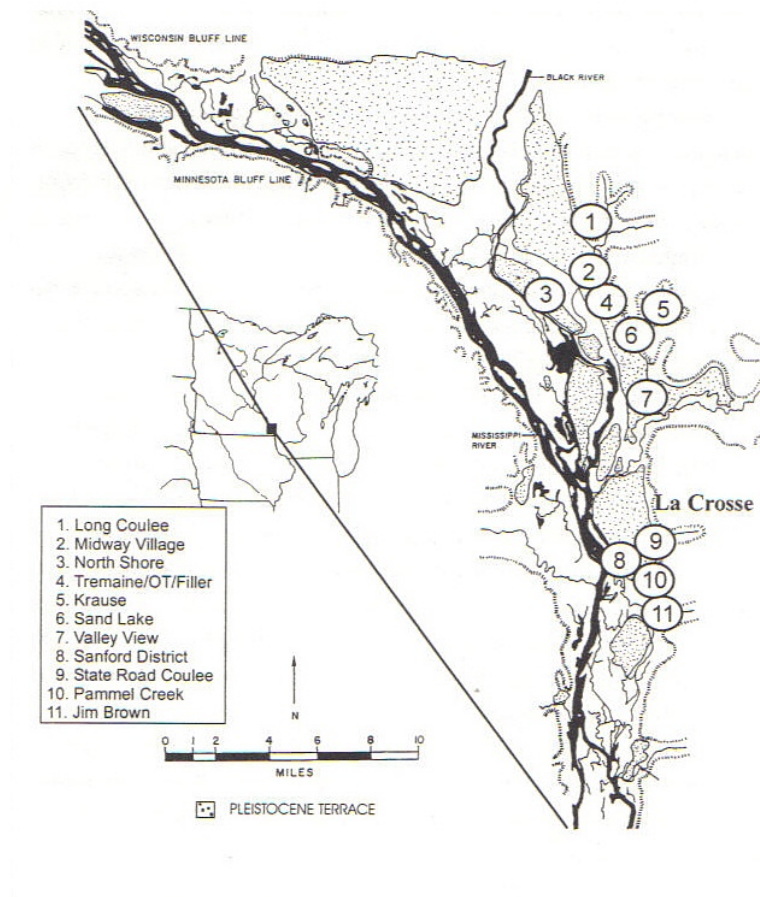
Typical methods of preparing corn for consumption were many and varied. One favorite way of preparing fresh green corn by the Hidasta was by boiling or roasting the

cobs during the green corn harvest held in August. Feasts of green corn prepared by such methods were usually enjoyed close to the fields (Wilson 1981, 1987, Will 2004). The Pawnee would often coat their roasted corn ears with either buffalo suet or bear oil for seasoning (Will 2004). Another popular dish was succotash, which is the combination of boiled corn and beans. This dish was popular amongst the Hidatsa, Mandan, Arikaras, Omaha, Pawnee and others. Parched green corn, parched ripe corn, or fresh green corn would be used with green or ripe beans and may have included the addition of other ingredients such as dried or fresh meat, marrow or fat, dried squash, or seasonally available berries such as choke cherries (Wilson 1987, Will 2004). The Otoes were known to make a boiled corn and bean bread that was baked in the ashes of a fire (Will 2004). Hominy, or leyd corn, also appears to have been a preferred recipe for the Hidatsas, Mandan, Arikaras, and Pawnees. To prepare hominy, the previous season's parched corn would be shelled from the cobs and boiled in water with wood ash, then rinsed in fresh water to remove the seed casings from the corn kernels and again boiled until soft and palatable (Will 2004). Ash crust from corn husk fires would also be collected and rolled into balls to add to succotash as seasoning (Wilson 1987). One additional preparation method for corn that was often employed by the Hidatsa and Mandan was the use of corn meal and boiled water or rendered fat to form a paste that would be eaten as a pudding or otherwise fried or baked as corn balls or bread. Often, the pulp of freshly ground corn, honey, or maple syrup would be added to such a mixture (Wilson 1987, Will 2004). It was with methods of corn preparation such as these, that my experimental models were created to test the processing methods of corn against the charred corn kernel samples of the Pammel Creek and Valley View sites.

Identification of Physical Qualifying Characteristics and Corn Type from the Archaeological Record

The decision to study the charred corn samples from the Pammel Creek and Valley View sites was made for three distinct reasons. First, I was given easy access to the floral samples from both sites since they were both housed at the Mississippi Valley Archaeology Center in La Crosse, Wisconsin. Second, both sites have had extensive analyses done. And third, each site represents a different period of occupation in the La Crosse locality, with Pammel Creek representing the Middle Horizon Pammel Creek Phase and Valley View representing the Late Horizon Valley View phase (Boszhardt 1994). The location of both sites can be viewed in Figure 2.

Figure 2: Oneota sites in the La Crosse locality (Theler and Boszhardt 2003).



Identification of the corn type and also qualifying characteristics of the charred corn kernels recovered from the Pammel Creek and Valley View sites were essential prior to experimentation. For the most part, only two portions of the corn plant are ever recovered from an archaeological context at Oneota sites: corn cupules (otherwise known as the fragments from where the kernels were held onto the corn cobs) and corn kernels (Arzigian 1989). Arzigian explains that “Kernels are remnants of food preparation and their charring reflects accidental losses” and through referencing Wilson (1987) explains cupules as “waste products that might have been deliberately burned to dispose of them, to produce ash for seasoning” or, through referencing Binford (1967), explains cupules as purposely burned to smoke meats or hides (Arzigian 1989, 1994).

In the Pammel Creek site report much attention is paid to the floral remains of the domesticate *Zea mays*, or corn. The site represents occupation by the Oneota culture from A.D. 1420 to 1520, as is suggested by the midpoints of 11 uncorrected radiocarbon dates taken from the site. Summary statistics are utilized to analyze abundance, relative frequency, and ubiquity of the corn kernels and cupules distributed through out feature levels, zones, and the Pammel Creek site in entirety; however, based on available research at the time, only two other characteristics of the corn kernels recovered were mentioned from Leonard Blake’s analyses: that kernels were crescent-shaped and “charred off the cob, as evident from their degree of distortion” (Arzigian 1989).

Katherine Stevenson (1994) and Robert F. Boszhardt (1994) have established that the Valley View site was likely occupied in the late 16th century and abandoned by A.D. 1625, as is suggested by the more reliable of two later radio carbon dates from the four uncorrected radio carbon dates taken from the site. Stevenson (1994) suggests that the

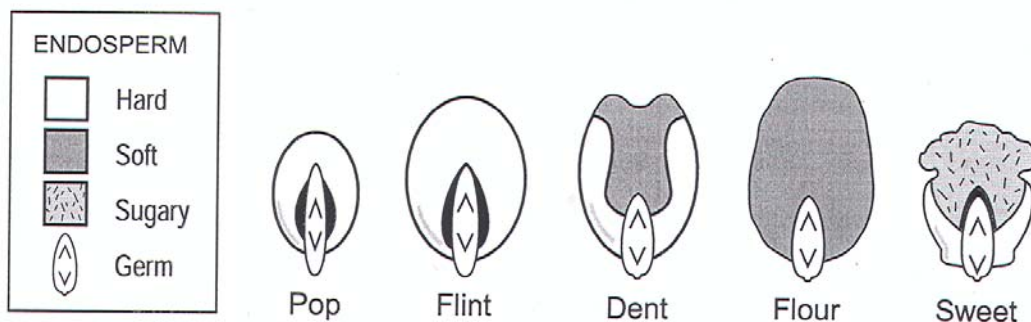
lack of density for “charred non-wood plant remains” despite the large size of the Valley View site is the result of rescue archaeology sampling procedures; nonetheless “corn fragments were [still] found in 90% of the features sampled...[and] The ubiquity of corn fragments suggests processing at the site (Stevenson 1994: 254).” Furthermore, a three to one kernel fragments to cob fragments ratio provides evidence for the burning of cobs (Stevenson 1994).

Through inspection under ten times magnification, other identifying characteristics other than those mentioned by Leonard Blake were able to be noticed of the recovered Pammel Creek and Valley View charred corn kernels. The majority of the samples of charred corn kernels were too small to discern any identifying characteristics under ten times magnification. A combined 13 kernels from the two sites demonstrated sufficient size to analyze. These yielded identifying characteristics that would later be compared to the charred corn samples that were produced from experimentation and include (a) surface quality, with typically smooth and hard endosperms often pocketed with areas of rough and porous distortion or small cavities, (b) kernel shape, which tends to be crescent shaped and rounded, (c) kernel side shape, which includes the typical rounded side and the atypical angular side, and (d) embryo preservation, which includes intact long and tapering embryos, partial embryos, and absent embryos with either a cavity on the ventral portion of the kernel or the topmost portion of the kernel is what that remains (for illustrations of these characteristics, please see the appendix). Interestingly, of the seven kernels large enough to analyze from the Pammel Creek site, only three kernels possessed intact or partial embryos. Of the five kernels large enough to analyze

from the Valley View site, only two kernels possessed intact embryos and one kernel possessed a partial embryo.

Additionally, the samples I analyzed were large enough to discern the most probable corn type recovered from the Pammel Creek and Valley View sites was a flint or semi-flint type. According to George W. Dickerson's (1992) classification of specialty corns, I was able to discern that the analyzed kernels from the Pammel Creek and Valley View sites were not a dent corn type since dent corn is a modern hybrid of northern flint and southern flour varieties. Also, the charred corn samples lacked any appearance of a dent on the kernel. Furthermore, the charred corn samples demonstrated a rounded kernel shape, a hard endosperm, and an elongated or tapering embryo that comprised at least half the length of the ventral side of the kernels. This eliminated the possibility that the type of corn used at these sites was a sweet or flour type since those kernels will exhibit respectively a sugary or soft endosperm and an irregular or square kernel shape. The characteristics of the different kernel types are illustrated in Figure 3 and the characteristics of the samples of charred corn kernels from the archaeological record are visible in the illustrations located in the appendix.

Figure 3: Endosperm distribution in five types of corn kernels (Dickerson 1992).



Identification of an Appropriate Heirloom Variety of Corn

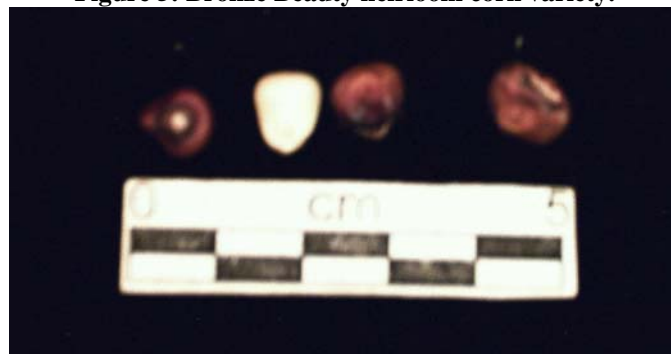
Identification and use of an appropriate heirloom variety of corn was essential for the experimentation in order to make sure that any of the identified characteristics from the experimental samples were the product of the processing method and charring and not the result of any variables from modern corn types.

Figure 4: Wa Ruch Skaw or Winnebago Flint heirloom corn variety.



Having already established that the corn type utilized at the Pammel Creek and Valley View sites was flint or semi-flint, I acquired seven samples of parched flint and semi-flint heirloom corn seed varieties. The corn varieties were affiliated with extant American Indian tribes that I had linked ethnographically to the Oneota culture.

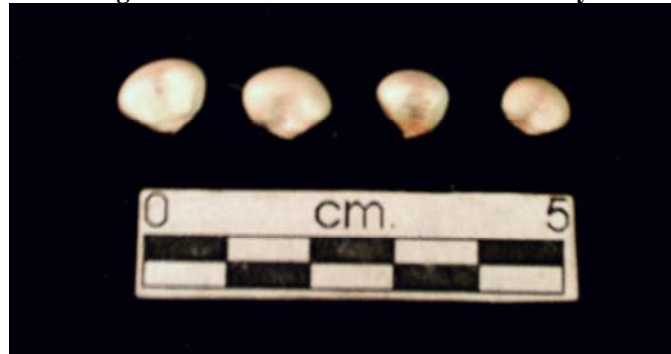
Figure 5: Bronze Beauty heirloom corn variety.



Via several electronic communications in 2008 with Mark Millard of the Agricultural Research Service of the United States Department of Agriculture, I was able to obtain six

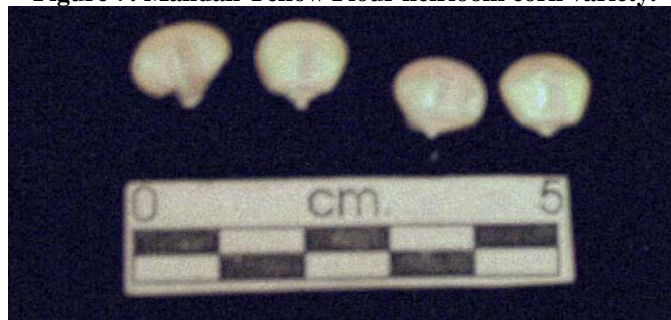
heirloom varieties were from the NCRPIS (North Central Regional Plant Introduction Station) located at Iowa State University in Ames, Iowa. Photographs of these varieties are available in Figures 4 through 9.

Figure 6: Fort Totten heirloom corn variety.



Of these varieties, Wa-ruch-skaw or Winnebago Flint of the Nebraska Winnebago demonstrated the necessary rounded and crescent kernel shape of the charred corn kernel samples from the Pammel Creek and Valley View sites, however this variety was not selected for experimentation because the embryos tended to be smaller and angular side shapes were rare for the kernels. Bronze Beauty, a flint type corn of the Ho-chunk Winnebago in Wisconsin, was decided against for use in experimentation because of its peculiar square to triangular shaped kernel, unusual color, and higher row number.

Figure 7: Mandan Yellow Flour heirloom corn variety.



The Fort Totten variety was likely the oldest of the heirloom seeds I acquired since it was rumored to have been removed in the 1830's from a cache pit located at a North Dakota Sioux village site abandoned because of a small pox outbreak. However, this

variety was also not chosen for use in experimentation because it was not available in large quantities.

Figure 8: Mandan Yellow Flint heirloom corn variety.



The varieties Mandan Yellow Flint, Mandan Yellow Flour, and Mandan Collection all demonstrated the necessary kernel shape, kernel side shapes, and large tapering embryos characterized with the charred corn samples from the Pammel Creek and Valley View sites.

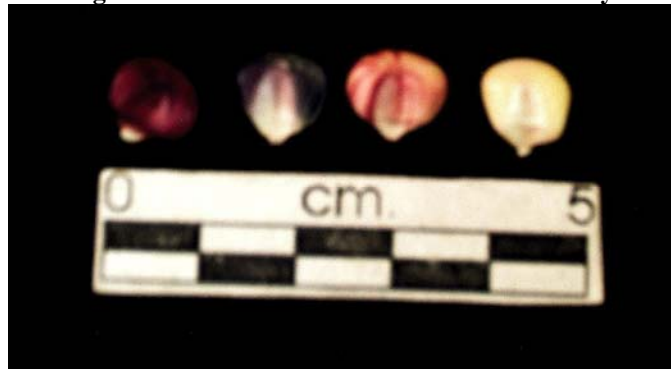
Since all the samples of Mandan heirloom seed seemed a plausible similar match for the corn recovered from the Pammel Creek and Valley View sites, I obtained another Mandan heirloom variety, Mandan Bride, from Seed Savers Exchange for use in experimentation since I was able to acquire it in the necessary large quantity (seven pounds).

Figure 9: Mandan Collection heirloom corn variety.



Mandan Bride also shared similar characteristics with the other Mandan varieties and was described in the Seed Savers Exchange online catalogue as a semi-flint type, also used as a flour corn originating “From the Mandan Indians of Minnesota and North Dakota. [It possess an] extensive color range, including some beautifully striped kernels (Seed Savers Exchange 2008).”

Figure 10: Mandan Bride heirloom corn variety.



A photograph of this variety is available in Figure 10 and detailed illustrations of its characteristics are located in the appendix.

Experimentation with Zea Mays (Corn)

Next, a series of experiments in corn cooking and processing methods were conducted in a cleared, outdoor space. The vessel utilized to process and char the corn was a six quart, enamel free cast iron Dutch oven. Other equipment utilized included an elevated steel fire bowl (so as to comply with La Crosse city laws), oak and pine fire wood, hydrated lime obtained from the hardware store, a mussel shell, a large spoon, grilling tongs (for handling the Dutch oven), and measuring cups. The corn made use of for the experimentation consisted of an unspecified variety of fresh sweet corn still on the cob purchased from a grocery store and the parched corn of the Mandan Bride heirloom variety. This was done in order to successfully char the corn in order to create viable

samples for comparison with the samples from Pammel Creek and Valley View sites. I assumed that most, if not all, corn kernels of satisfactory quality were not intentionally burned by past peoples and must have been forgotten or unattended in order to allow sufficient burning that would result in corn kernel preservation. Therefore, all experiments consisted of processing the corn according to the specified method and then neglecting the corn past the point of optimal processing time that would have yielded an edible product.

Experiment A consisted of roasting fresh sweet corn on the cob over an open fire. Experiment B consisted of boiling fresh sweet corn kernels that had been removed from fresh corn cobs with a mussel shell, and also my thumb nail, as was in compliance with the methods described by Buffalo Bird Woman to Wilson (1987). The shelled corn was then boiled with two parts water to one part corn in the pot over an open fire. Figure 11 documents Experiments A and B in progress.

Figure 11: Experiments A and B in progress.



Experiment C consisted of boiling parched corn kernels with equal parts water in the pot over an open fire. Experiment D consisted of making and boiling hominy. This was a more involved process which relied on the recipe for Mexican hominy given to me by

Chef Aaron Storduer via a personal communication in 2008. The recipe utilized lime instead of lye or wood ash, and was not adapted since there was no exact recipe for the making of hominy with lye or wood ash found in the ethnographic literature. The prepared hominy was boiled with equal parts water in the pot over an open fire.

The hominy recipe used is as follows:

In a large vessel cover two pounds of parched corn kernels with at least two inches of water. In a separate container, stir in one tablespoon of lime with a half a cup of water to create a slurry. Then, mix the slurry with the soaking parched corn and boil the mixture for 15 minutes until the seed coats begin to split.

Remove the corn from the heat when this happens, cover, and let the mixture soak overnight. Lastly, drain the corn from the water and rinse the kernels to remove the seed coats before drying the hominy for preservation or boiling the hominy for consumption.

Lastly, a visual comparison of the samples was conducted between the corn recovered from the Pammel Creek and Valley View sites with the samples of charred corn procured from the five above mentioned experiments. The experimental samples were examined under ten times magnification and examples illustrated in order to show any qualifying characteristics the charred corn kernels displayed that were independent or shared with the samples from Pammel Creek and Valley View.

Results

Experiment A: Roasting Fresh Corn

Figure 12: Charred corn cobs and degraded kernels are the results of Experiment A.



The roasting of two cobs of fresh corn of an unspecified sweet variety over an open fire yielded a successful charred sample for the purposes of comparison with corn recovered from the Pammel Creek and Valley View sites. The two cobs actually twisted in shape due to the process of being neglected in intense heat for the intended purpose of charring. The sides of the cobs exposed to the coals of the fire were severely degraded. Kernels were damaged past the point of usefulness for comparison and portions of the cob are exposed. However, on the reverse side of the cobs, kernels were charred but not too heavily damaged and remained intact on the cobs. Visual documentation of the degradation to the corn cobs from Experiment A is available in Figure 12.

Even from the process of gentle handing and transportation into a plastic storage bag, several kernels were knocked loose from the cobs. These kernels demonstrate several key characteristics when viewed under ten times magnification. First, the surface of the endosperms are heavily distorted, appearing bubbled, porous, and rough. However, it is important to note that sweet corn types are more susceptible to damage under intense heat due to the sugary and soft structure of their endosperms (Dickerson 1992). Second,

some of the kernels exhibited angular sides while some maintained continuous rounded edges, as was the case with the fresh corn before it was processed and charred. Third, several of the kernels exhibited the presence of an embryo. Fourth, of the kernels that exhibited intact embryos, two of them were charred on the endosperm but not on the embryo. It is a fair speculation that if left to the elements, the portion of the corn kernel not charred would likely not be preserved, leading to the possibility of producing charred corn kernels missing their embryos. Lastly, significantly smaller pieces of charred corn kernel have broken off the other kernels and do not lend to easy identification of characteristics while under magnification. All of the identified characteristics may be viewed in the illustrations of the examples from the experimental samples in the appendix.

Experiment B: Boiling Fresh Corn

The boiling and purposeful neglect of two cobs worth of removed fresh corn kernels of an unspecified sweet variety over an open fire yielded a successful charred sample for the purposes of comparison with corn recovered from the Pammel Creek and Valley View sites. Again, it is worth mentioning that the majority of the corn kernels were heavily damaged or lost their embryo in the process of removal from the cob via this researcher's thumb nail and also with a mussel shell. Kernels prior to processing were either the top portions of the kernel with a large cavity on the underside, were the entire kernel absent of an embryo, or were small pieces of the body of the kernel. Visual documentation of these kernels is present in Figure 13.

Figure 13: Corn kernels with absent embryos due to removal from the cob prior to Experiment B.



These kernels exhibited several characteristics when viewed under ten times magnification. First, endosperms are heavily distorted, exhibiting bubbling, rough and porous areas, and cavities associated with the top most side of the kernel. Again, I shall reiterate that sweet corn types are more susceptible to damage under intense heat due to the sugary and soft structure of their endosperms (Dickerson 1992). Second, of the kernels large enough to determine distinct sides, angular and rounded sides were present. Third, the majority of the sample is missing their embryos. Cavities where the embryo should be are present on some kernels while other kernels consist of only the topmost portions of the kernel and have their heaviest areas of distortion on their underside. Fourth, of the kernels that still do possess an embryo the kernels appear greatly shriveled and distorted in shape around the embryo. No exact kernel shape (such as round or square) can be discerned for the kernel. Lastly, at least half of the sample is composed of broken kernel pieces too small for easy identification of any characteristic under magnification. All of the identified characteristics may be viewed in the illustrations of the examples from the experimental samples in the appendix.

Experiment C: Boiling Parched Corn

The boiling and purposeful neglect to produce charring of one cup of parched corn over an open fire yielded a successful charred sample for the purposes of comparison with corn recovered from the Pammel Creek and Valley View sites. These kernels exhibited several characteristics when viewed under ten times magnification. First, for the most part the surface of the kernels remained hard and smooth, with small portions of their endosperms being pocketed with areas of rough and porous distortion. No major cavities are present on the kernels. Second, while the initial shape of the kernels is still recognizable (crescent and round), most of the kernels appear to have swelled slightly from processing causing rounded sides to be more prolific than angular sides. Also, angular sides appear less severe. Third, almost the entirety of the sample consisted of kernels with intact embryos. Fourth, a portion of the sample is of broken kernel pieces that are too small for easy identification of any characteristic. Lastly, an intriguing characteristic was noticed for only a couple of the kernels in the sample; that being embryos were absent from the kernel and the remaining kernel exhibited an overall crescent like shape. Of these kernels, distortion to the surface of the kernel was minimal. All of the identified characteristics may be viewed in the illustrations of the examples from the experimental samples in the appendix.

Experiment D: Boiling Hominy

This experiment proved the most difficult because it involved the most variables. The preparation of the hominy took place using parched kernels of the Mandan Bride variety of corn and hydrated lime 24 hours prior to actual processing. Boiling of the

freshly made hominy and purposefully neglecting it over an open fire yielded a successful charred sample with which to compare to the corn samples from the Pammel Creek and Valley View sites. However, I would like to note that I am dissatisfied with the initial result of the hominy prior to processing. When rinsed after soaking the allotted time in the lime solution, the kernels sloughed off a portion of their pericarps and had visibly changed color. However, I feel that too much of the seed coats were present on the hominy. I feel that this has affected my results for the charred sample of hominy.

Nonetheless, the kernels were examined under ten times magnification for any identifying characteristics. First, there exist some large, indiscernible starchy and porous lumps that are not readily noticeable as kernels. Second, the degree of distortion on the surface of the kernels varies, with some kernels' endosperms remaining smooth and hard, to some kernels exhibiting pockets of rough and porous distortion on their endosperms, to kernels with endosperms completely distorted. Third, as with the kernels from Experiment C, most of the kernels appear to have swelled slightly from processing causing rounded sides to be more prolific than angular sides. Also, angular sides appear less severe. Lastly, the majority of the kernels have retained full or partial embryos. All of the identified characteristics may be viewed in the illustrations of the examples from the experimental samples in the appendix.

Conclusions

In Table 1 the identified characteristics for the charred corn samples produced from experimentation are clearly outlined. There are several correlations I find to be of key interest. First, charred corn samples produced from sweet corn appear more heavily

distorted on the surface of the endosperm. This can be viewed in illustrations of the samples available in the appendix. This matched my expectations; since Dickerson (1992) explains that sweet corn endosperms are soft and sugary and therefore can be inferred to suffer a higher degree of distortion when exposed to high heat. Additionally, the kernel shape of the sweet corn samples and the extreme level of endosperm distortion are not present on the archaeological samples of charred corn kernels from the Pammel Creek and Valley View sites. Second, the fresh sweet corn samples retained the presence of both rounded and angular side shapes that had existed prior to processing of the corn. I infer that the presence of angular and rounded kernel side shapes is a characteristic resulting from the kernel's placement on the cob and has no affect on processed fresh corn.

Table 1: Identified characteristics associated with charred corn kernels produced from experimentation.

	Endosperm Surface	Overall Kernel Shape	Kernel Side Shape	Embryo	Cavities On or Surrounding Embryo
Experiment A (Fresh Sweet/Roasted)	Heavily distorted (bubbling, flaking, porous, and rough)	Resembles unprocessed form	Resembles unprocessed forms (angular or rounded)	Intact (some not charred)	Yes
Experiment B (Fresh Sweet/Boiled)	Heavily distorted (bubbling, flaking, porous, and rough)	Resembles unprocessed form	Resembles unprocessed forms (angular or rounded)	Absent (typical) and partial (atypical)	No
Experiment C (Parched Semi-Flint/Boiled)	Lightly distorted (rough and porous areas)	Swollen (overly crescent and rounded)	Rounded	Intact or partial (typical) and	Yes

				absent (atypical)	
Experiment D (Parched Semi- Flint/Hominy)	Varies from little to complete (i.e. indiscernible) distortion	Swollen (overly crescent and rounded)	Rounded	Intact or partial (typical) and absent (atypical)	Yes

The charred parched corn samples took on a swollen kernel shape, causing the angular side shape that existed prior to processing to almost disappear. Also, the charred parched corn samples for the most part retained intact or partial embryos. This was an unexpected development; however the presence of cavities on or around the embryos from these samples are very common and suggests to me that this would have made this portion of the kernel susceptible to loss when disposed of and made subject to depositional processes. Further research would be needed to verify this inference. Also important to note, is that while the charred hominy samples exhibited varied levels of distortion, a higher degree of distortion (i.e. explosions of starchy mass from the inside of the kernel) is more prevalent with kernels lacking most of their pericarp. Therefore, I believe if the hominy was prepared correctly, this processing method would not resemble what is found in the archaeological record. Further research could be performed in order to indicate if the complete removal corn kernel pericarps during the production of hominy prior to additional processing and charring would yield different identifiable characteristics if (a) a different heirloom variety of corn (i.e. a flint type instead of a semi-flint type) was utilized, (b) a higher concentration of lime was used during hominy production, or (c) wood ash lye was utilized in stead of lime during hominy production.

Also, it would be interesting to determine if there would be any identifying characteristic visible on the molecular level for corn processed in the various experimental methods.

The above mentioned correlations lead me to conclude that the charred corn kernel samples from the Pammel Creek and Valley View sites are the product of boiling parched corn. While parched corn was demonstrated in the ethnographic research to have been utilized year round, it was most heavily relied upon as a food staple during the winter and spring months before the green corn harvest would have become available (Wilson 1981, 1987, Will 2004). This implication of at least some level of occupation during the winter and early spring months at the Pammel Creek and Valley View sites is also supported by the suggested Oneota seasonal round and floral and faunal evidence of pit features from the Pammel Creek site (Arzigian et al 1989).

Acknowledgments

Thank you to Dr. Constance M. Arzigian of UW-La Crosse for guiding me through me through the construction of my research plan, pointing me in the direction of fantastic resources, lending her expertise concerning paleo-ethnobotany, and finally for reading and critiquing this paper. Also, much thanks to Dr. Joseph Tiffany of UW-La Crosse for helping me to locate and identify an heirloom variety of corn seed to use in my experimentation, suggesting very helpful literature, and for reading and critiquing this paper. I'd also like to express my appreciation to Dr. James L. Theler and his Senior Thesis class at UW-La Crosse, for encouraging and critiquing my research and paper. Also, a special thanks to Chef Aaron Storduer for his culinary expertise, knowledge of cooking vessel surfaces, and help with hard to find hominy recipes. And a final word of gratitude to my husband, Samuel T. Hall, for starting fires for me in the back yard and assisting with the process of experimentation. You have all helped considerably in the compilation of this work.

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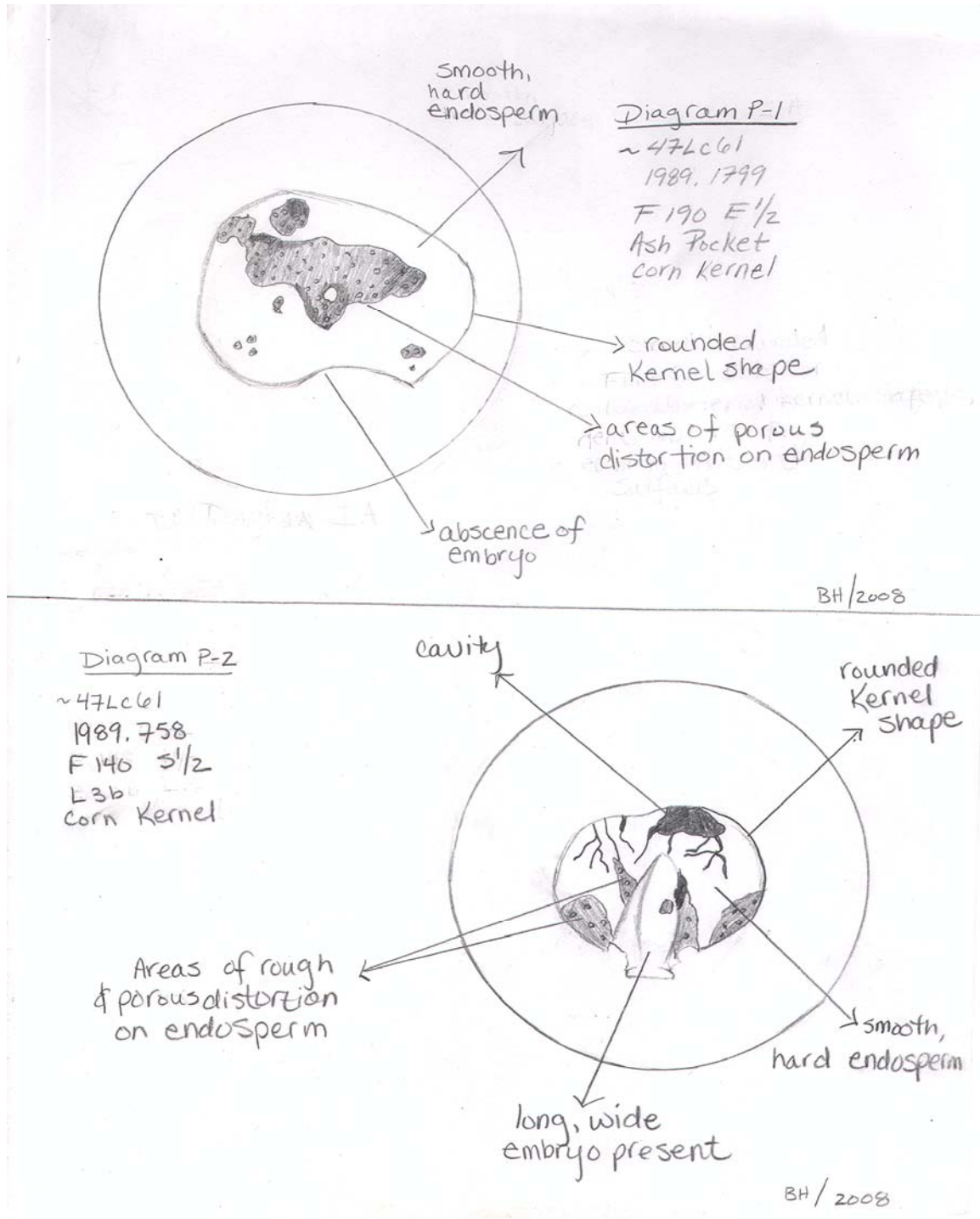
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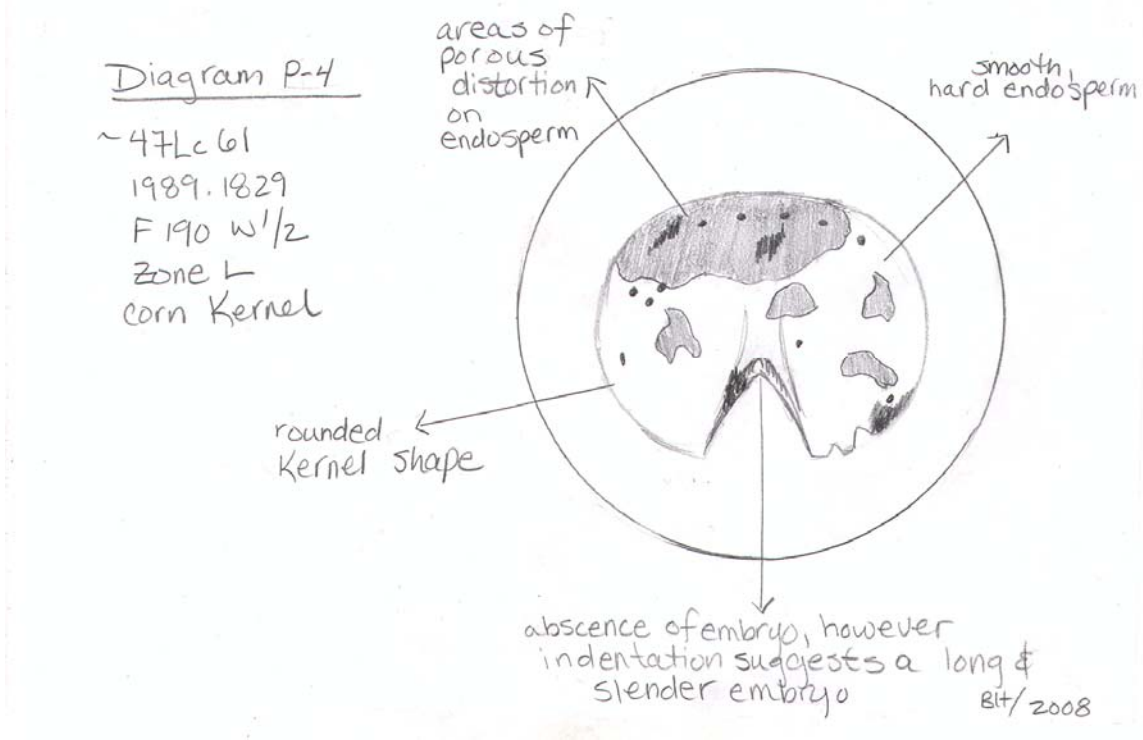
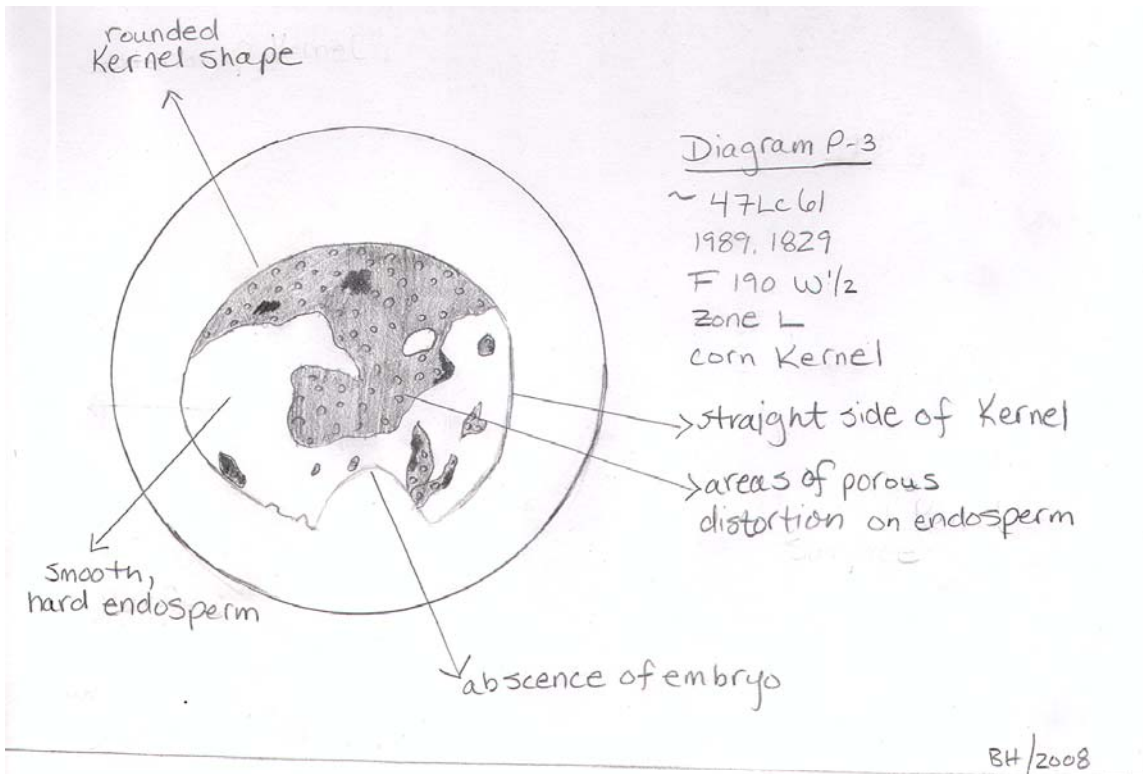
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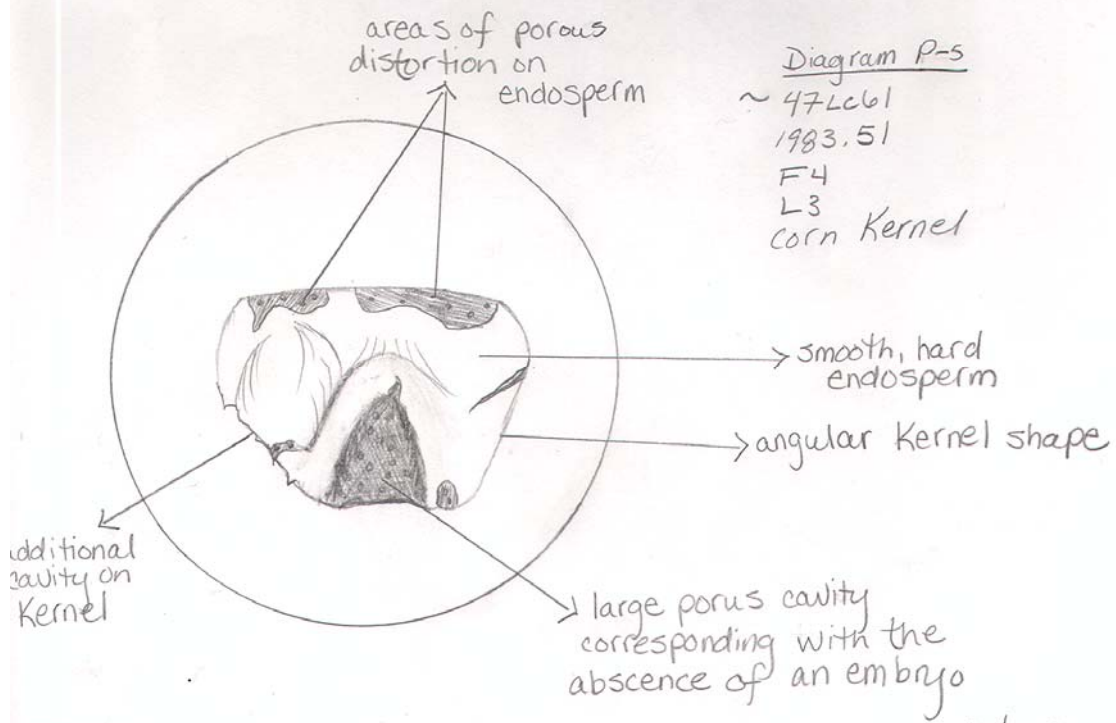
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Appendix

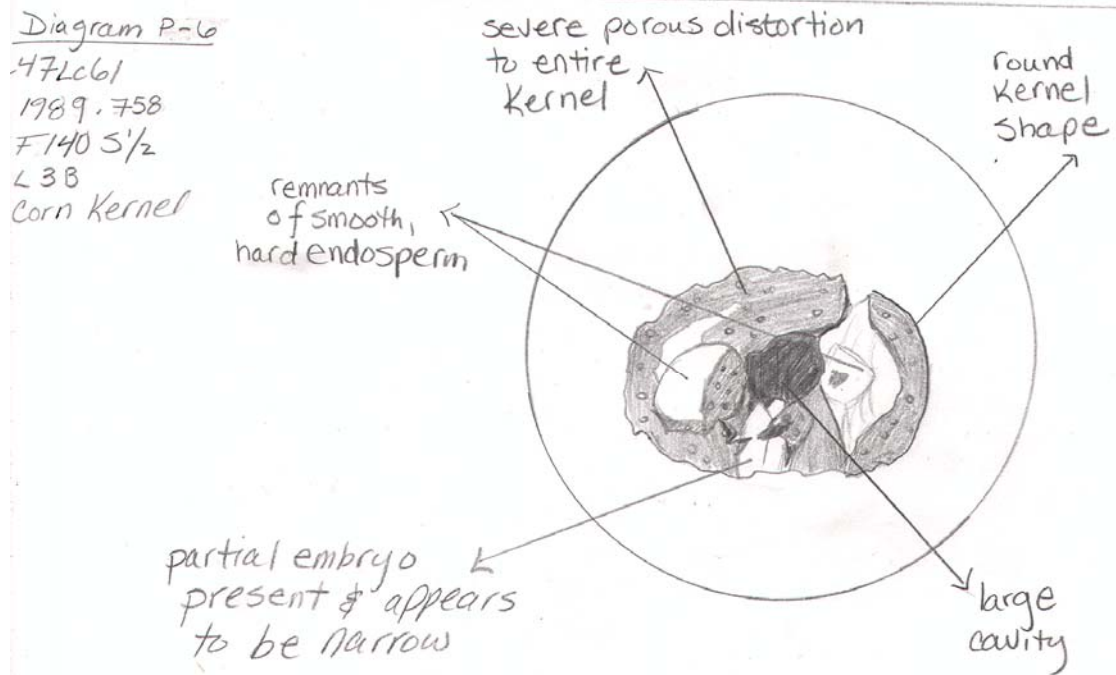
Note: "P" classified diagrams illustrate corn kernel samples from the Pammel Creek Site (47Lc61), "V" classified diagrams illustrate corn kernel samples from the Valley View Site (47Lc34), "M" classified diagrams illustrate Mandan Bride variety parched corn kernels, while diagrams classified as "A" through "D" illustrate corn kernel samples from the experiment correlating with their respective letter.







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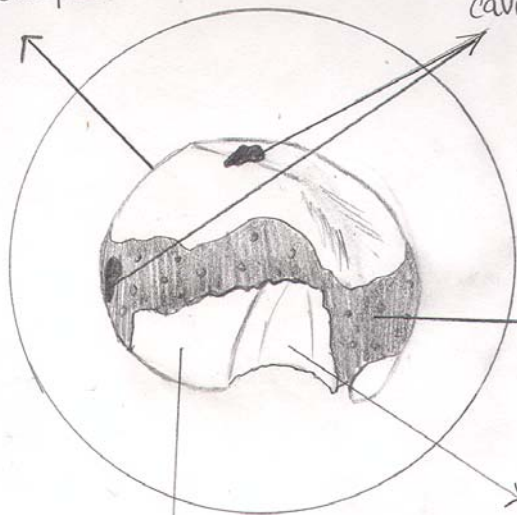


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Rounded Kernel
Shape

Diagram P-7

~47Lc61
1983.290
F24
L1
corn kernel



Areas of rough &
porous distortion on
endosperm

partial embryo present,
possibly long & slender

hard, smooth
endosperm

BH/2008

Diagram V-1

~47Lc34
1979.360.02
M525
F.36

hard, smooth
endosperm

Areas of
rough, porous
distortion
on endosperm

cavities

rounded
kernel shape

complete
embryo present, long & slender

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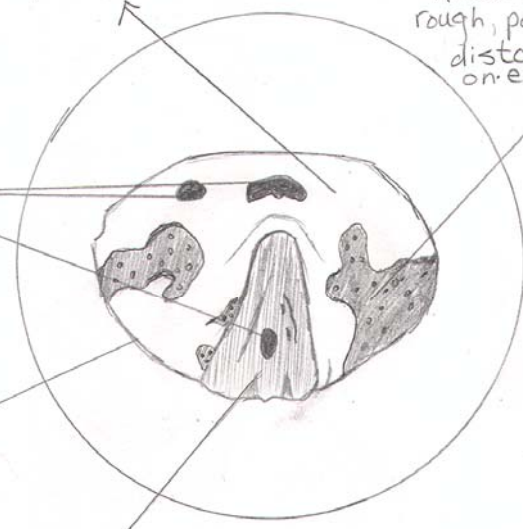


Diagram V-2

~47Lc34

provenience unspecified

* Note: Top of Kernel,
cavity & absence of
embryo on underside

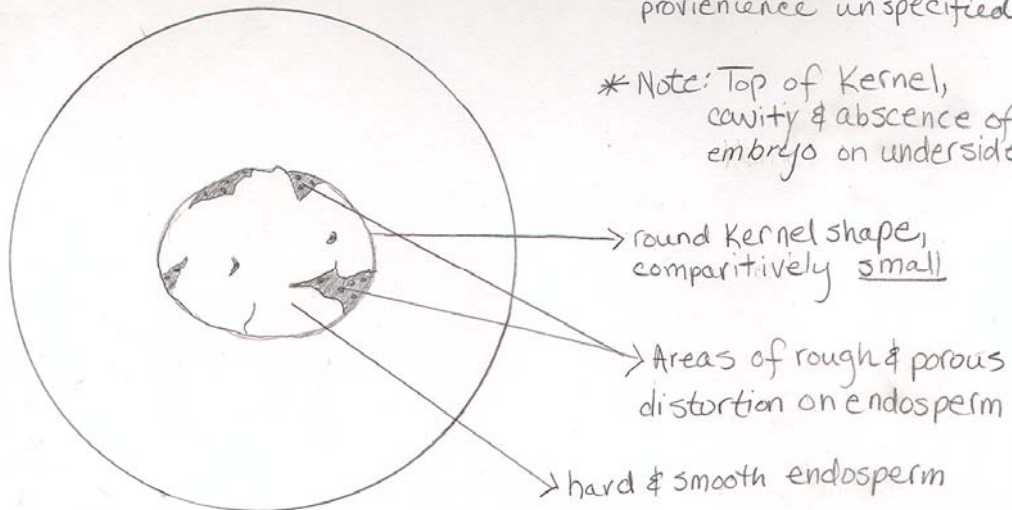
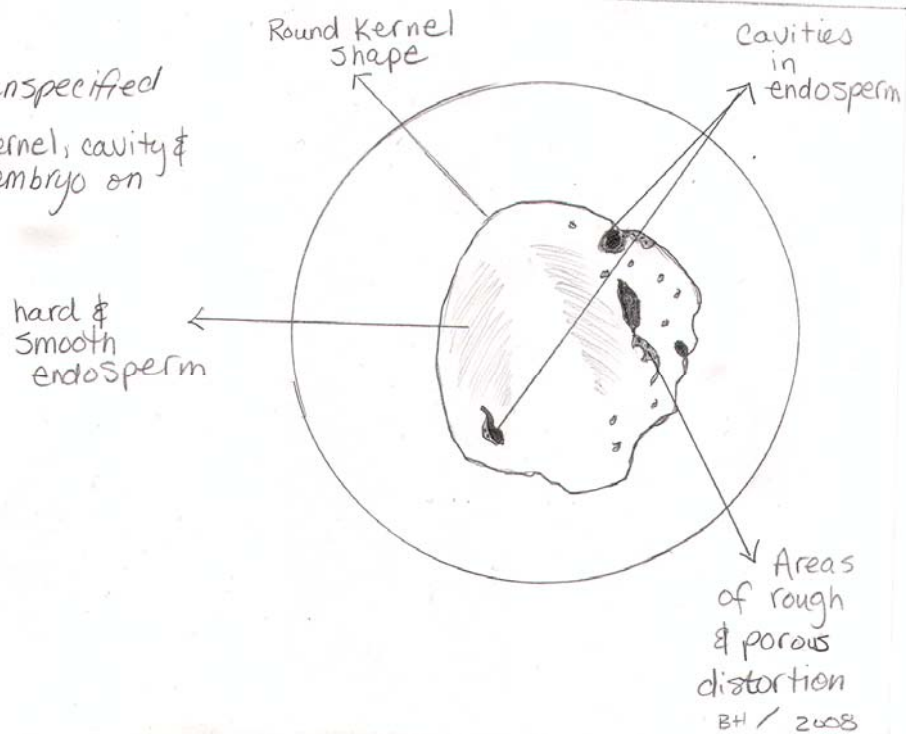


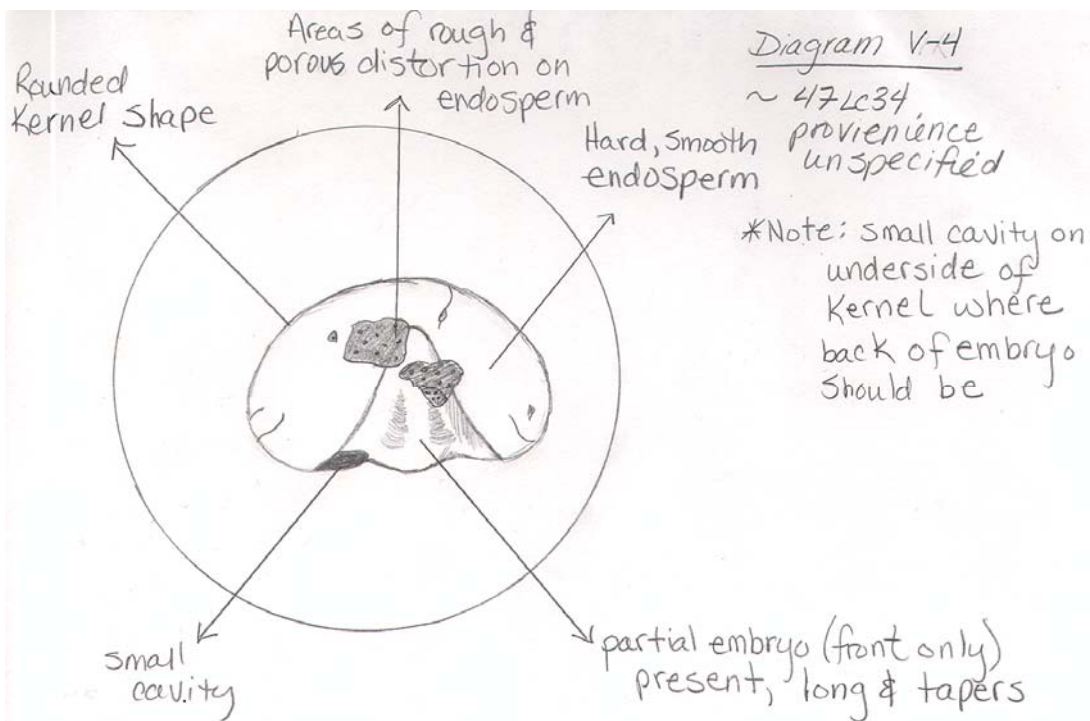
Diagram V-3

~47Lc34

provenience unspecified

* Note: Top of Kernel, cavity &
absence of embryo on
underside



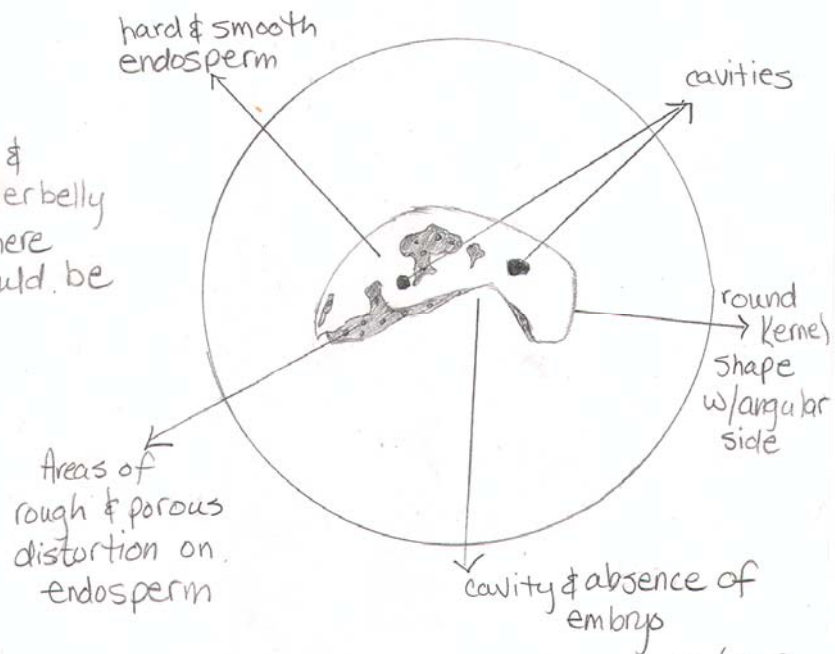


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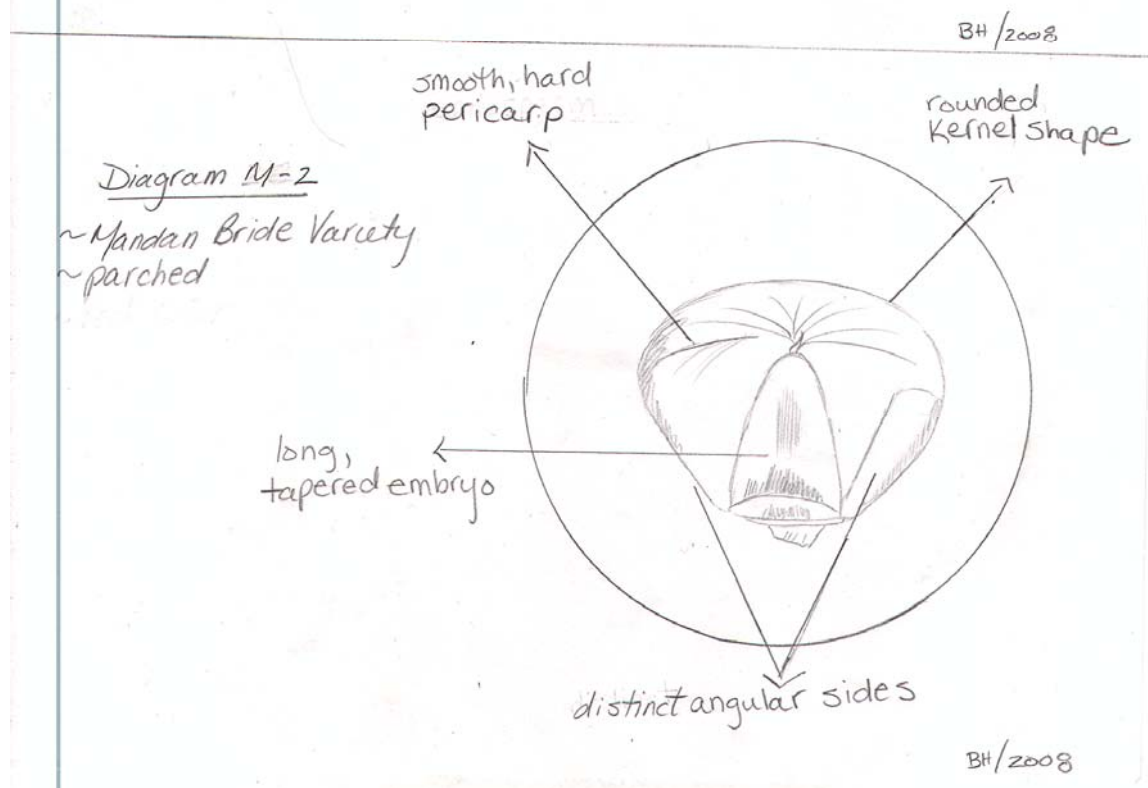
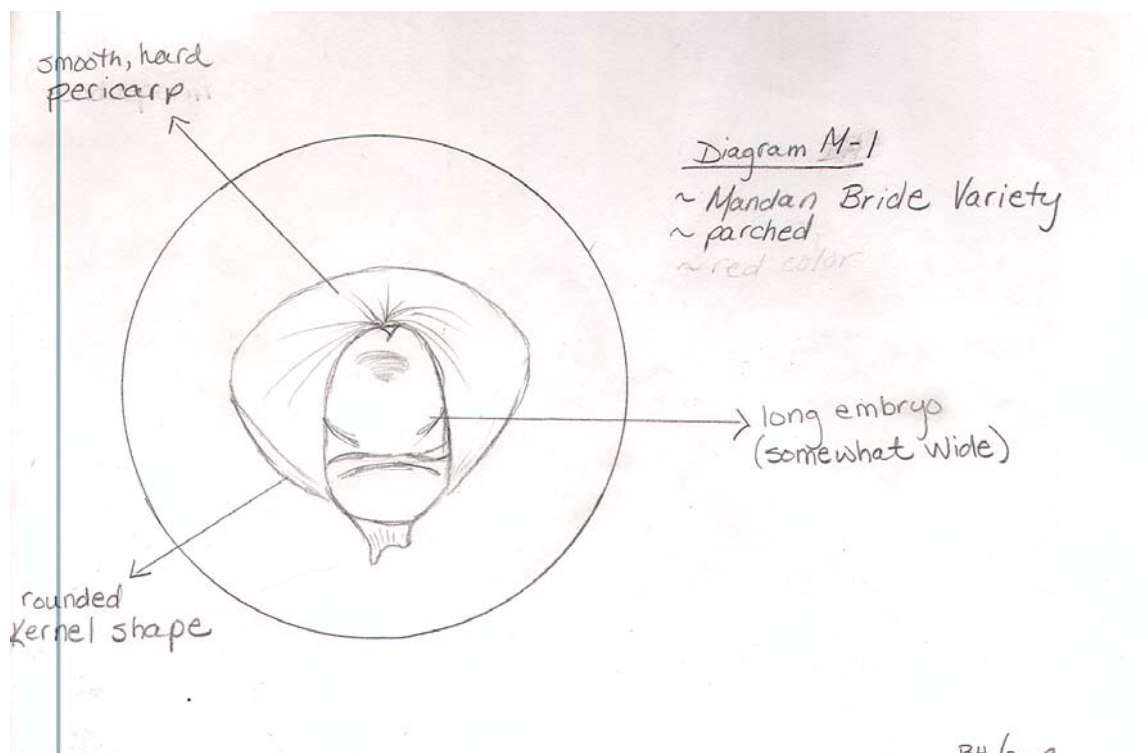
Diagram V-5

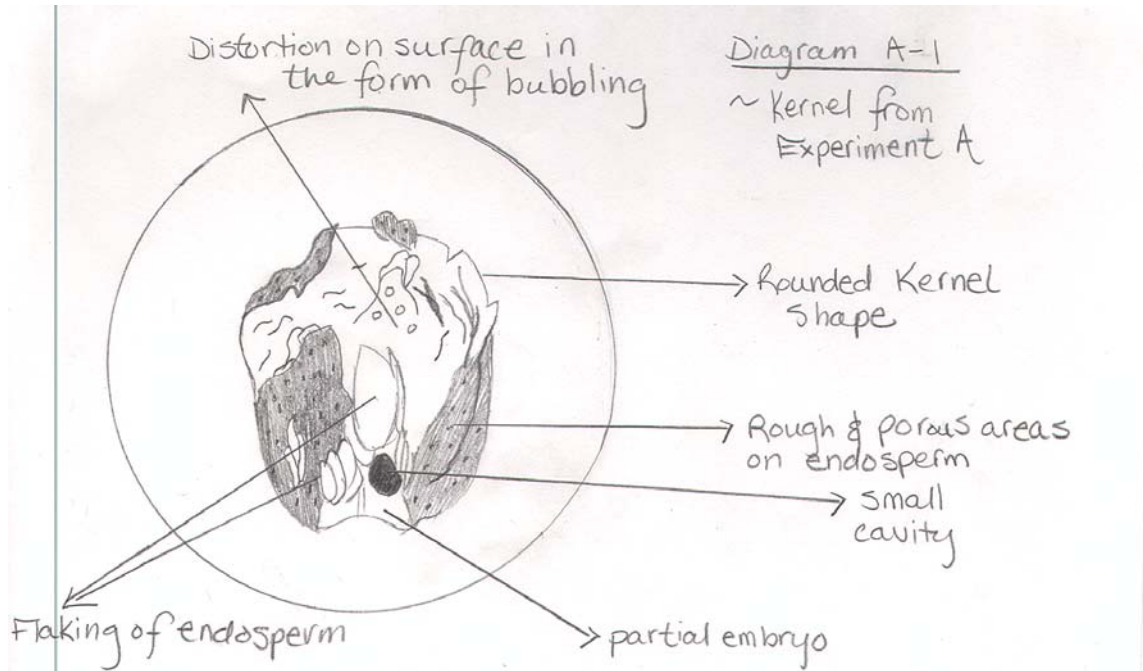
~ 47Lc34
Provenience unspecified

*Note: Small kernel & cavity on underbelly originating where embryo should be

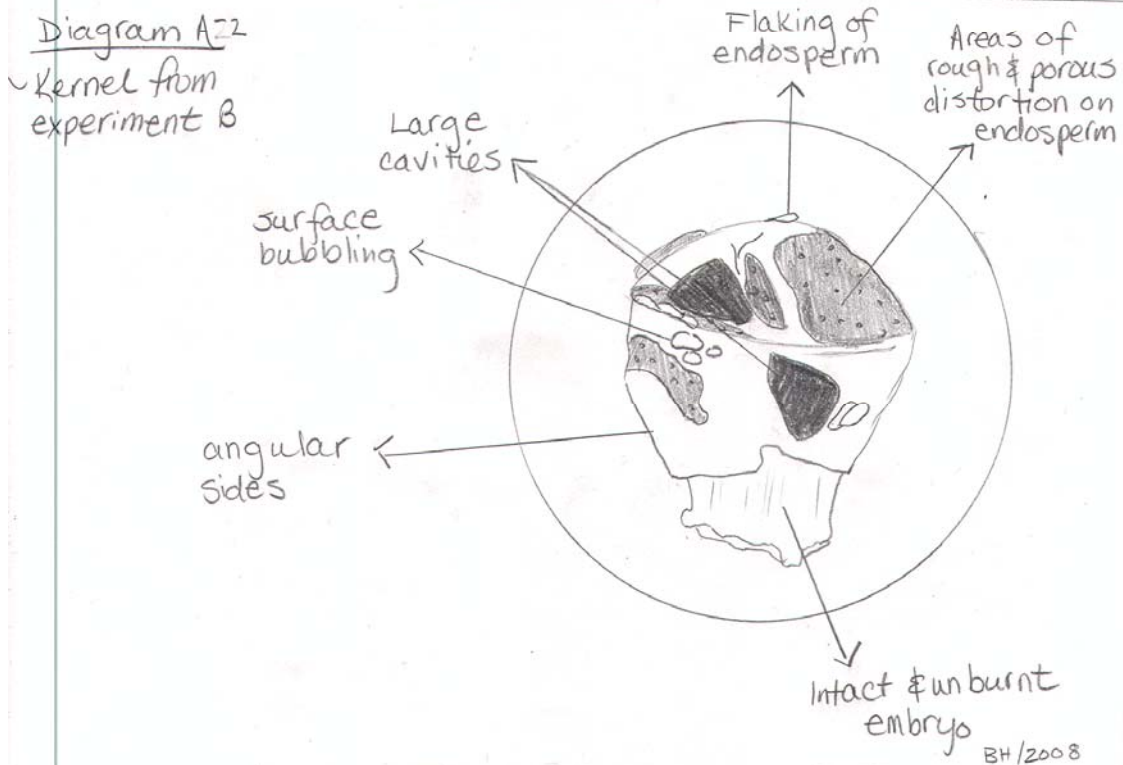


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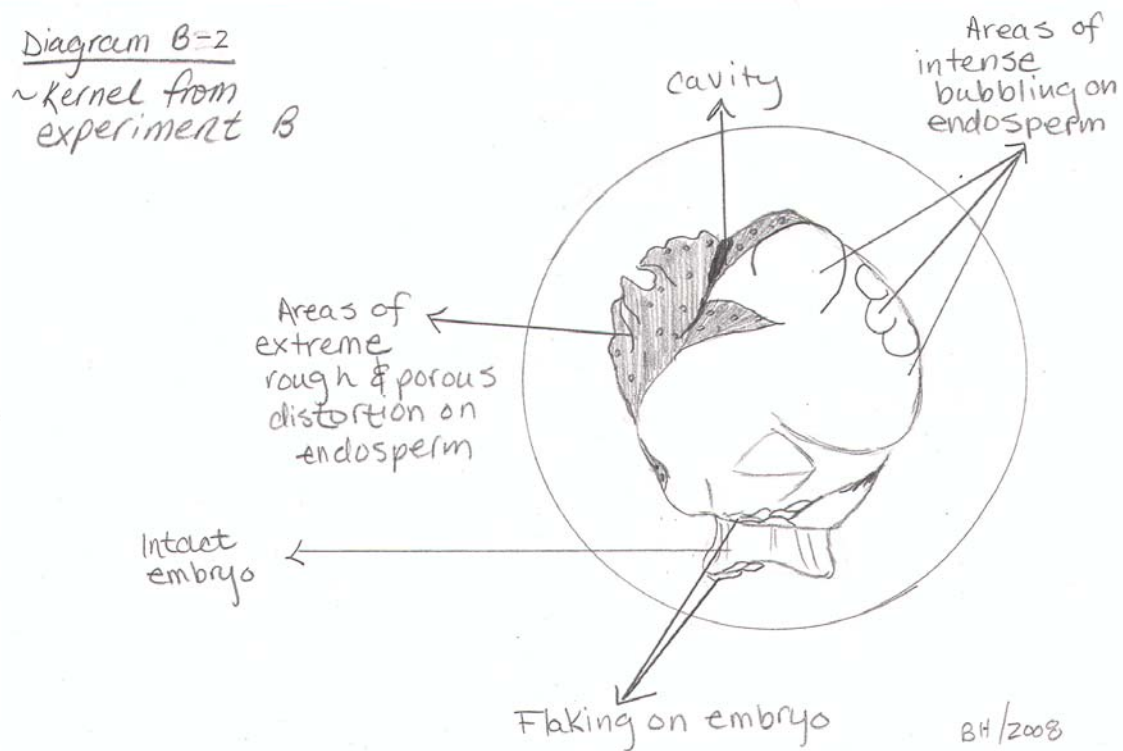
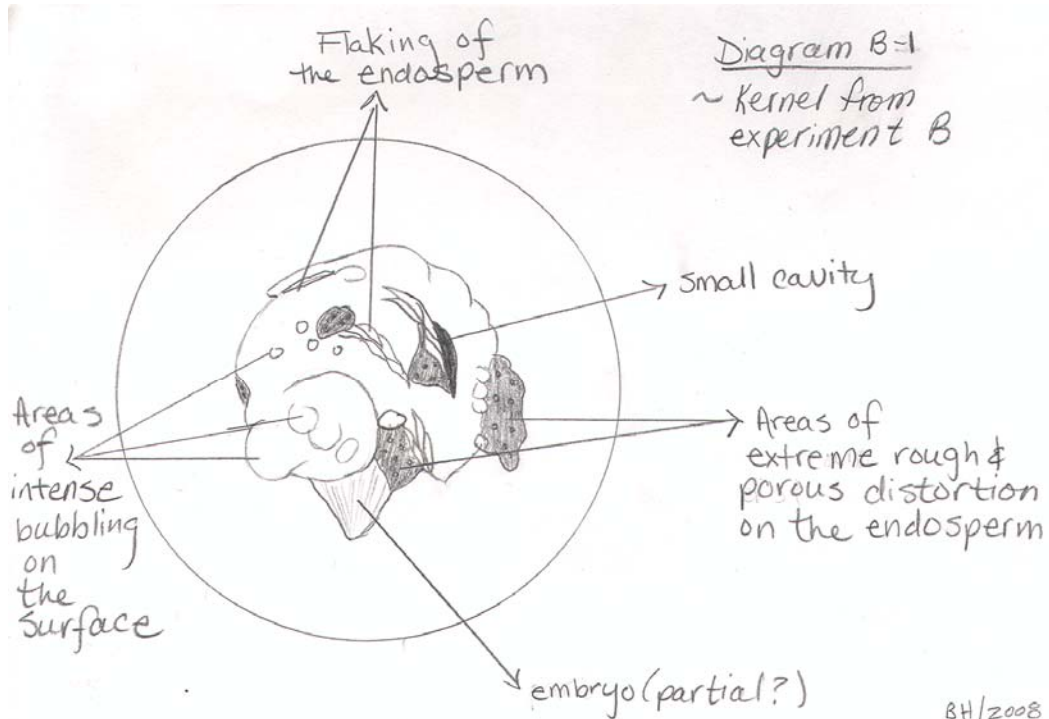


Diagram B-3

~ Kernel top from experiment B

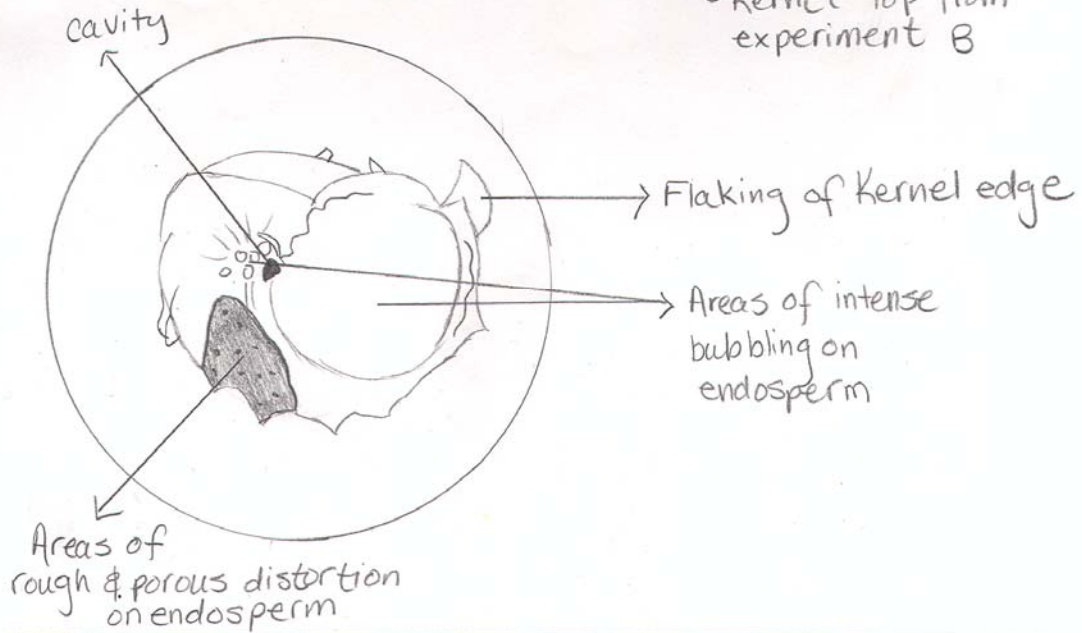


Diagram C-1

~ Kernel from experiment C

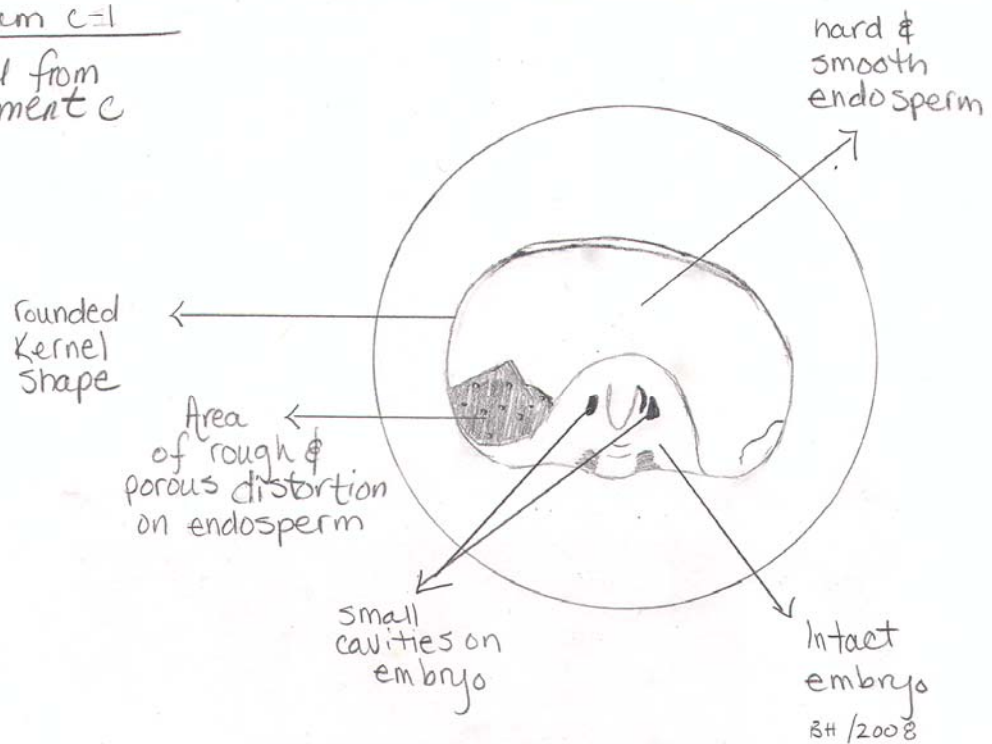


Diagram C-2

~ Kernel from experiment C

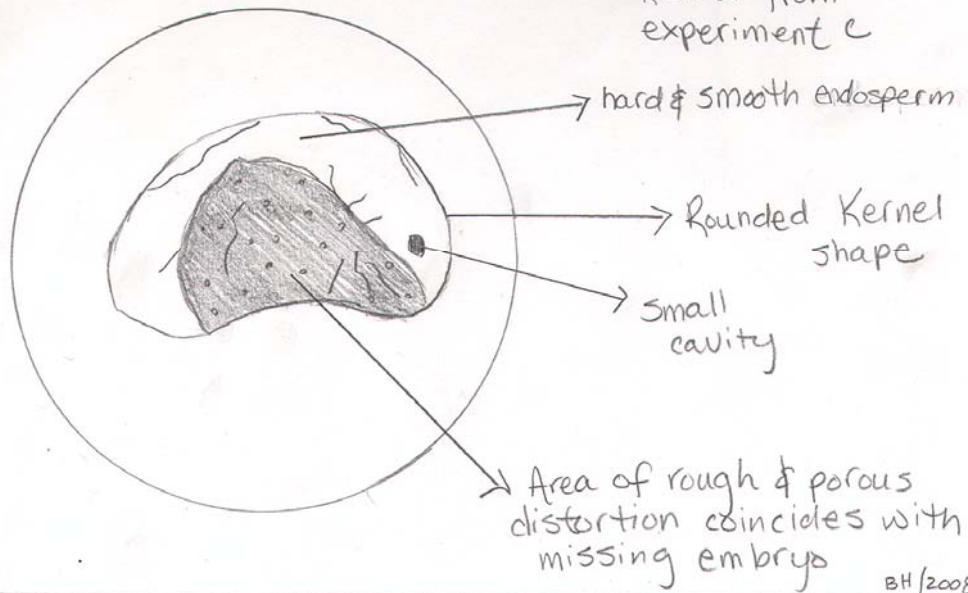


Diagram D-1

~ Kernel from experiment D

