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The scientific research programmes of Lakatos and applications in parasitology

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Summary:

The methodology of scientific research programme (MSRP) proposed by Lakatos was in the line of the proposals made by Popper. MSRP were intended for constructing and evaluating research programme, which is unique among philosophers of science. Surprisingly, scientists dedicated to research in mathematics, physic or biology have not used much MRSP. This could be due to the fact that scientists are not aware of the existence of MSRP, or they find it difficult to apply to their own investigations. That is why we present firstly the main characteristics of this methodology (hard core – the group of hypothesis that are admitted by experts in the field, auxiliary hypotheses – which are intended to protect and refine the hypotheses of the hard-core, and heuristics for mending and evaluating the MSRP) and, secondly, propose an example in helminthology. We think that the methodology of Lakatos, is a useful tool, but it cannot encompass the large flexibility of investigations pathways.

KEY WORDS : Lakatos, philosophy of science, helminth, parasite, research programme.

Scientists are nowadays highly specialised and they hardly encompass the field of their own science. At the beginning of the 17th century, it was assumed that scientific knowledge is produced by several individuals but it was possible for any individual to integrate all the existing knowledge, and in best cases, to increase it (Saint-Sernin, 2007). At the end of the 19th century, the different parts of sciences were not any more integrated in a whole but disjointed into parallel knowledge (Saint-Sernin, 1995). We are also confronted with the alliance of science and technique. "*The 20th century has seen, if not the birth, at least the development of an alliance between science and technique which is called biotechnology. Technology is characterised by a contrast: highly accurate in its means and its results, and fuzzy on the future effects and side-effects. Its nature is to be enthusiastic and blind. It is fully movement, virtuosity, utility; technique ignores where it goes and what it does*" (Saint-Sernin, 1995). Biohumanities is a view of the relationship between the humanities (especially philosophy and history of science), biology and society: it should overcome the limited alliance of technique and science. In this vision, the humanities not only comment on the significance or implications of biological knowledge, but add to our understanding of biology itself (Stoz & Griffith, 2007). Philosophy of science may help to figure out the relationships between science, technique and societal demand, although it is not an evidence for everyone. "*Physicist Richard Feymann is supposed to have said that philosophy of science is no more use to science than ornithology is to birds. In this paper we will try to show that this is very far from the truth. The complex and often troubled relations between science and society are critical to both parties, and the philosophy and history of science can help to make this relationship work. They may be as valuable to science as conservation biology is to birds*" (Stoz & Griffith, 2007).

Philosophers of science are often very far away from the ordinary scientists. "*The task of modern philosophy of science whose aim is the reconstruction of scientific methodology must be a comprehensive view of the scientific enterprise. It must take into consideration all factors that influence the acceptance or rejection of hypotheses and theories and must attempt to understand the mutual interaction of those factors*" (Sattler, 1986). Systems models may apparently come closest to full representation of scientific methodology. Lazlo (1973) general systems model of the evolution of science could appear as easy of use for biologists. The systems model addresses to the crucial question of which factors determine retention or replacement of hypothesis. Lazlo (1973) founded value on a balance of empirical adequacy and integrative generality, although it is not easy to determine this balance. Scientists then rely on philosophers of science which are highly theoretical or systems' philosophers that appear as more in tune with reality, although their constructions are not really usable by scientists.

Lakatos (1978) developed a methodology of scientific research programmes and has then a unique position

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among philosophers in that respect. It remains that very few literature on the real use of the methodology of scientific research programmes is very limited as we found in the Web of Science database (from 1992 to 2007), either in biology, mathematics and physics or social sciences (less than 20 records). Lakatos has been the source of research programmes in folk psychology: "*the Lakatosian model may seem promising – particularly to those who are interested in studying the development of children's understanding of the mind – the analogy between Lakatosian research programs and folk psychology cannot be made good because folk psychology does not possess anything analogous to the positive heuristic of a Lakatosian research program. I also argue that Lakatos' account of theories may not be the best one for developmental psychologists to adopt because of the emphasis which Lakatos places on the social embeddedness of scientific theorising*" (Wringe, 2002). Metham (1993), a biologist, did view the development and the formulation of an apparently resilient theory of milk secretion (based on a key role of glucose on regulation) over the last 30 years as conform to the notion of progressive research programme and positive heuristic, as proposed by Lakatos.
The scientific research programmes have also been used in parasitology (Denegri, 1991, 1996, 1997; Denegri & Cabaret, 2002). Our intention in this mini-review is to see how Lakatos programmes: i) are different from the Popper (and others) philosophical proposals in science; ii) help to construct a general framework for host-helminth parasite assemblages, and it will be taken as an example to clarify the methodology of scientific research programmes (MSRP).

LAKATOS, POPPER AND FEYERABEND

THE DIFFERENT ATTITUDES TO RESEARCH AND SCIENCE

Lakatos (1922-1974) has played a special role in philosophy of science, due to his short life and background, and his close relationship with Popper, the dominant philosopher at the London School of Economics during the same period. Lakatos correspondence with Feyerabend (in Motterlini, 1999) shows that he has, with all his gravity, the secret of lightness. The philosophy of Lakatos has been developed *pro* and *contra* Popper. His PhD, "*Essays on the logics of mathematical discovery*" is a paraphrase of "*The logic of scientific discovery of Popper*" (1959), and it is in the *pro* phase. Much of the *contra* is in the "*Popper on demarcation between science and pseudoscience, and induction*" (Lakatos, 1974) edited by Schlipp. Although Lakatos stated that disagreement was not based on highly different opinions but rather on very small differences, which were enough not to see research programmes with the same eye. Differences are major in our opinion. Thus, the research programmes of Lakatos are a demonstration of the relative autonomy of theory in science, when the set of conjectures and refutations of Popper are not organised. Lakatos proposes a positive solution to induction, in order to escape from the provocative anarchism of Feyerabend. We have to be very careful, Lakatos did not intend to give researchers advices "*My methodology deals with fully fledged research programmes, but has no intention to of handing out de vice to the scientist on how to arrive at good theories or on which of two rival theories he should work on*" (in Motterlini, 1999).
According to Matheson (1996) "*Lakatos's theory of rationality is based on the idea of the research programme, which is a sequence of theories characterized by a* hard-core *(the features of the theories that are essential for membership in the research programme), the protective* belt *(the features that may be altered), the* negative heuristic *(an injunction not to change the hard core), and the* positive heuristic *(a plan for modifying the protective belt)*".
"*Usually we are faced with what I call a hard core of two, three, four, maximum five postulates. Consider Newton's theory: its hard core is made up of three laws of dynamics plus his law of gravitation… Instead of directing the modus tollens (*e.g *instead of A implies B, the contraposition is non-B implies non-A) of refutation to the hard core, one leads it against these auxiliary hypotheses, which in this sense, create a protective belt around the hard core*" (Lakatos, 1973).
The protective belt is altered for two reasons. In its early stages, a research programme will make unrealistic assumptions (*i.e.* Newton's early assumption that the sun and the earth are point masses). The protective belt is altered in order to make the programme more realistic. It becomes testable only when it has achieved a sufficient degree of realism. Once the programme has reached the phase of testability, the protective belt is altered when the programme makes false experimental predictions. The alterations to the protective belt are not equal. Those alterations that allow the research program to make a novel prediction, then the alteration is said to be progressive. If the alteration is only an ad hoc manoeuvre, that is, it does not lead to any novel prediction, it is regarded as degenerate. Lakatos & Zahar (1976) extended the definition of novel prediction to cover phenomena that may have been observed before the time of prediction but which were not among the problems which the alteration was designed to solve.
Lakatos (1978) indicates that a research programme is in 'good health' as long as a sufficient number of the alterations to it are progressive. "*So I have replaced the descriptive unit in science. I shall not ask anymore whether a hypothesis is true or false anymore, or even whe-*

ther a problem shift is good or bad; what I shall ask is whether a research programme is progressive or degenerating". He explains how it is degenerating "*It is degenerating if-during growth when we add layers of mathematical techniques to its protective belt – 1) it does not lead to stunning new predictions (at least occasionally, like Newton theory did over two and a half century); 2) all its bold predictions are falsified [proven to be inexact]; and 3) it does not grow in steps which follow the spirit of the programme*". As stated by Matheson (1996), "*Lakatos does not provide us with details concerning ways to measure degeneracy, nor does he locate the point at which degeneracy can prove fatal to a research programme*". Matheson (1996) furthermore pointed that it remains difficult to compare one theory to another. *"In particular he* [Lakatos] *would have to tell us what it is for one theory to have more observable content than another. If he presupposes some sort of cumulativity principle (* i.e. *that the better theory says everything true about observables that the worse one did plus a little bit more) than his theory is historically implausible. If he denies cumulativity, then the problem he faces,* i.e. *that of providing a sound basis for observational content, has foiled all who have tried to solve it*".

Matheson (1996) asked much more than that was delivered by Lakatos: a methodology to evaluate the value of a research programme, its dynamics rather than to compare with other programmes. It is distinct from Popper's views since hypothesis can be falsified but the evaluation is not on hypotheses but on the whole programme, and its heuristic value. It is completely different from Feyerabend (1975) who was definitely against method.

A GENERAL FRAMEWORK FOR HELMINTH RESEARCH IN HOST-PARASITE ASSEMBLAGE

From life cycle to ecology

This framework has been presented in Denegri & Cabaret (2002) and Denegri (2008). We present it here in a way that parasitologists could grasp better the concepts of hard core and auxiliary hypotheses.

• The hard core is: the knowledge of the alimentary chain of hosts explains and predicts their intestinal parasitic helminth fauna

This idea is present in Marcogliese & Cone 1997. It has been also been reviewed extensively in fish parasites (Williams *et al*., 1992). Taking the example of Anoplocephlidae cestodes, the exclusive or partly herbivory of ruminants and equids explains that they harbour adult or larval stages of the worms. The hard core is a decision of a scientific community which is irrefutable.

There are many indications that the hard core is the rule. For example in the cestode family Anoplocephalidae (in Denegri, 2008), it is found that anoplocephalids are numerous and belong to many species in dedicated herbivores (sheep with *Avitellina centripunctata*, *Helictometra giardia*, *Moniezia benedeni*, *Moniezia expansa*, *Stilesia hepatica*, *Stilesia globipunctata*, *Thysaniezia giardi*, *Thysaniezia ovilla*, *Thysanosoma actinoides*) whereas in limited herbivores the number of species is limited (*Bertiella mucronata*, *Bertiella studeri* in human and non-human primates). A second example is presented by Denegri (1993) and is based on the trophic behaviour of oribatids mites which are intermediate hosts of Anoplocephalidae cestodes. According to the trophic classification of oribatid mites, the plant eater and the animal eater were the most infested. A third example concerns the Metastrongyloidea nematodes, for which gastropods are acting as intermediate hosts (Anderson, 2000). Three types of infection modes are found: *i)* in herbivores, with accidental ingestion of gastropods or larvae liberated onto the grass; *ii)* in insectivores and rodents gastropods constitute an important part of the diet and infections are frequent; *iii)* among carnivores, a transport or paratenic host plays an important role.

• The protective belt (auxiliary hypotheses) is constituted of two groups of hypotheses, *i)* on life-cycle, and *ii)* on the development of helminth communities

The hypotheses on life cycle are constructed after Boskov (1986):

- All trematodes, cestodes and acanthocephalans are parasites; nematodes are either parasites or free living organisms.
- Trematodes, cestodes and acanthocephalans are hosted by animals, whereas nematodes can be hosted by plants or animals.
- All adult acanthocephalans are parasites of vertebrates, the majority of trematodes and cestodes are parasites of vertebrates but many adult nematodes are also parasites of invertebrates.
- Only several species of nematodes are parasite of invertebrate during larval life and free living when adults.
- The development of secondary biological cycles is found in trematodes, cestodes and some nematodes parasite of vertebrates; these secondary life cycles are not present in acanthocephalans.
- The number of hosts is 2 to 4 in trematodes, 2 to 3 in cestodes, 2 in acanthocephalans, and 1 to 3 in nematodes parasites of vertebrates.

The hypotheses on communities are based mostly on Price (1987). Four models are presented, based on the concept of vacant niche and competition between species:

- The non-asymptotic model: the species accumulate along time in the host, without any apparent saturation of the species community.
- The asymptotic equilibrium, based on the biogeography of islands (Mac Arthur & Wilson, 1967), the equilibrium depending on colonization and extinction rates.
- The asymptotic equilibrium: it is a variant of the preceding model.
- The model of co-speciation (Brooks, 1979).

The auxiliary hypotheses can be modified without affecting hard core and the value of the research programme. Suppose that a trematode is found as a free-living organism. We will have only to modify the first hypothesis: "all trematodes are parasites" becomes "the vast majority of trematodes are parasites". It is not a negative heuristic (a reason to change the hard core). Conversely, a new fact such as a "a group of nematodes penetrate through the skin and infect hosts independently of their food habits" may induce to alter the hard core. The infection of *Strongyloides* is representative of such a situation in herbivores. It has been found in more frequently in small ruminants reared indoors (this the majority of records in temperate zones: see among others, Cabaret *et al.*, 1986) but it can also be found in lambs grazed outdoors and gathered at night in places called "kraals" ("zriba" in Mauritania: Cabaret, 1976) in order to better control predation. In that case, food chain does not predict at all the prevalence of infection by *Strongyloides*. This nematode is a possible reason for modifying the hard core, and is that a negative heuristic. We could modify the auxiliary hypotheses so that this nematode is excluded from the general nematode group. We could propose the following modification in of the auxiliary hypotheses: nematodes having an extra-intestinal migration are not included. If we then think of nematodes harboured by wild rodents we will have quite a few species that migrates within hosts and are either orally transmitted or not. Then we should find some further hypothesis to protect the hard core. If these situations are frequent and finally constitute the main operations within the research programme, we should question how far we will go to protect the hard core. Positive heuristic is when we can predict a helminth fauna based on alimentary chain. Suppose we discover a new host, comparable to roe-deer in a temperate region. If we identify a helminth fauna similar to roe-deer in this new host, it is a positive heuristic. The importance of diet is demonstrated in Anisakids (Anderson, 2000). *Anisakis simplex* are parasites of pinnipeds and cetaceans, and larvae has been found free in the haemocel of euphasid shrimps, and the role of all eaters of shrimps remains in question (marine mammals can acquire larvae from eating infected fish, crustacean or squids). Thus the diet as a unique filter for parasites should be refined, possibly by enrichment of auxiliary hypotheses.

DISCUSSION AND CONCLUSIONS

Philosophers of science are in an uneasy situation: science grows by "itself", and the role of philosophers is not always clear. Should they restrict their interest to the "passed" results of science? Or should they be more offensive and propose tracks for future avenues of science? The methodology of research programmes by Lakatos answers rather the second question, although it may prove useful to understand historical cases, as shown in *Dicrocoelium dendriticum* life-cycle elucidation (Denegri, 1997). The attitude of Lakatos in his methodology for scientific research programme is quite near to Louis Pasteur attitude (maintain as much as possible a hard core, without taking into account small deviations) rather than that of Claude Bernard (who was ready to investigate on deviations that could possibly modify the hard core of the theory) (C. Debru, 2007, ENS Paris, personal communication on Pasteur and Bernard research organisation). Lakatos attitude is thus one possibility for very efficient research (the Pasteur diverse and highly innovative researches). We should consider that it is not the only possibility for constructing research: the Bernard physiological findings are extremely important and were not acquired with a Lakatosian view of hard core, they are rather in agreement with Feyerabend absence of method (1999, in Motterlini): "*Neither science nor the methodology of research programmes provide arguments against anarchism. Neither Lakatos nor anybody else has shown that science is better than witchcraft and that science proceeds in a rational way. Taste, not argument, guides our choice of science*". Researchers might be puzzled by these two extreme considerations. We think that the methodology of scientific programmes is a really powerful tool for building a new research, evaluating its outcome (see Metham, 1993) but it is not the only way for successful research. The tool is fairly simple, it is a good way to start a research, and it is rarely used: we should promote this tool. We should also keep in mind that progress in science (and parasitology is no exception) is somewhat unpredictable. *"Science, after all, is our creature, not our sovereign; ergo, it should be the slave of our whims, not the tyrant of our wishes*" (Feyerabend, 1999 in Motterlini).

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