THIS IS BIOLOGY. ERNST MAYR AND THE AUTONOMY OF BIOLOGY AS A SCIENCE

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INTRODUCTION

The status of biology as an autonomous science has been frequently discussed by biologists and philosophers of biology. What does "autonomy" mean? While (recently) nobody has seriously claimed that biology can be separated from the other (natural) sciences or can stand isolated among them, there are good arguments against a reduction of biology to physics and chemistry. In many of his writings, particularly in *This is Biology* (1997), Ernst Mayr argues that biology requires methods, explanations, and theories of its own. He shows that the science of the living world seeks answers to questions that physics and chemistry cannot answer—and even do not pose. Also, he points out that biology requires its own philosophy, the more so since philosophy of science was dominated for many decades by physics. In this paper I give a brief account of Mayr's arguments for the autonomy of biology that are indeed most stimulating for a (new) philosophy of biology. Besides, I argue that young biology students can learn a lot from Mayr's approach, his thinking and reasoning about the science of life.

It is quite evident that historicity, the historical aspect, plays a major role in biology. Thus, in a recent paper, Mayr (2000, p. 80) states:

> Evolutionary biology, in contrast with physics and chemistry, is a historical science—the evolutionist attempts to explain events and processes that have already taken place. Laws and experiments are inappropriate techniques for the explication of such events and processes. Instead one constructs a historical narrative, consisting of a tentative reconstruction of the particular scenario that led to the events one is trying to explain.

However, historicity in (evolutionary) biology is only one of the aspects that supports the "autonomists" against the "provicialists" who claim "that

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at best biology is a province of physical science, a dependency that can advance only by applying the methods of physical science and ... the methods of physical and organic chemistry" (Rosenberg 1985, p. 16).

It is obvious that organisms follow (and are constrained by) fundamental physical laws. Organisms cannot evolve and develop independently of (or against) the law of gravitation, for example, but they show distinctive characteristics not found in other natural objects. This implies that the autonomy of biology as a science is determined by the specificity of its objects, living systems, exhibiting features qualitatively different from those present in the inanimate world. Biologists have to look for answers to questions unknown to physicists (and chemists). A frequently quoted example is the question "What for?" (see, e.g., Simpson 1963). It refers to the purpose of particular biological structures (cells, organs) and behavioral traits, and is indeed unknown to physicists (Lorenz 1978) since it requires teleological explanations. Reductionism—the conviction that biology can be methodologically and ontologically reduced to physics (and chemistry)—has become, as it seems, obsolete. Reduction and reductionism in biology have, of course, many aspects (see Hoyningen-Huene and Wuketits 1989) which I will not pursue further in the present context.

EVOLUTION AND THE HISTORICAL APPROACH IN BIOLOGY

When reconstructing the evolutionary development of organisms, evolutionary biologists are in a similar situation as historians and archaeologists are regarding the longest period of our own history. They cannot ask eyewitnesses, and the events in question cannot be experimentally tested. However, they try to reconstruct what happened on the basis of empirical evidence, including artefacts, buildings, pieces of art, writings, and other kinds of human expression. Thus, many periods of our history are well-recorded. Evolutionary biologists are of course confronted with bigger dimensions of time, but they also can refer to an enormous wealth of empirical data (obtained from paleontology, biogeography, embryology, molecular biology, and other disciplines) that give evidence for evolution in general and for the evolutionary pathways of particular groups of organisms, as well as particular species (see Mayr 2001).

Evolutionary biology is a historical science, evolutionary theory a historical theory and different from theories in physics (Mayr 1982, 1997, 2001, 2002). Evolution encompasses single, unique, and irreversible phenomena, such as the emergence of terrestrial vertebrates, the evolution of flowering plants, the extinction of the dinosaurs, and the origin of humans. Moreover, it tries to explain the origin of evolutionary novelties, trends in the phylogenetic development of diverse groups of organisms, the tempo and mode of evolution, etc. The evolutionary biologist is confronted with the questions "Why?" or "How come?" (see Simpson 1963, 1980). The answers are to be found in historical reconstructions or historical narratives. In fact, one cannot imagine an experimental test of, for example, the extinction of dinosaurs. We know that they disappeared some 65 million years ago and, in order to understand why they faded away, we have to reconstruct the circumstances of this remarkable event. In doing so, we must gather geological, climatological, and other data. It now seems that the mass extinction at the end of the Cretaceous period was due to an extraterrestrial impact (see Alvarez and Asaro 1990).

This is not to say that experimental work does not play any role in evolutionary biology. Textbooks refer to mutation experiments and artificial-selection experiments that show how genetic change can occur (for examples, see Ayala and Valentine 1979). According to the principle of actual causes or actualism—introduced by nineteenth-century geologists, particulary Charles Lyell—we can roughly say that the present is the key to the past (see Gould 1987; Mayr 1982; Oeser 1996). If one believes in general natural laws, then he or she will have good reasons to argue that the same (or similar) conditions in the present and in the past will cause the same (or similar) effects. This does not mean that we can explain historical events exclusively on the basis of present—experimentally testable—events. Historical reconstructions or narratives remain the core of evolutionary biology as far as it is concerned with "large-scale" events and changes, such as the emergence of new *Baupläne* (body plans), the pathways of insect evolution, the transition from reptiles to birds and mammals, the evolutionary development of hominids, and so on and so forth.

The point here is, as Ernst Mayr has never been tired to state it, that historical reconstructions or narratives are scientifically not less valuable than physical theories; that they are heuristically useful, and that evolutionary biology as a historical science is quite different from the physical sciences. Moreover, Mayr has claimed that evolutionary biology resembles in many aspects the humanities rather than the natural sciences. He has always, and for good reasons, opposed a philosophy of science dominated by physics and demand that everything that applies to physics should apply to all other scientific disciplines. Mayr (1969, 1988) explicitely stated that many biological phenomena have no equivalent in physics and are therefore omitted from any philosophy of science that is based on physics. This does not mean that physics and biology are basically in conflict or that the philosophy of physics is inconsistent with the philosophy of biology. However—and this has always been Mayr's concern—we have to admit that there are specifically biological questions and problems that cannot be handled in terms of physics (and chemistry). Historicity or the historical aspect in (evolutionary) biology is a good basis not only for the autonomy of biology but also for an autonomous philosophy of biology.

A philosopher of biology is forced to deal with the nature of historical narratives, which can be omitted by a philosopher of physics.

EVOLUTION AND THE DIVERSITY OF LIFE

The diversity of life is another consideration. "Life is a dynamic system of populations in constant change" (Ayala and Valentine 1979, p. 1). Millions of species are now around and, according to Mayr (1982), we may assume that the number of species that became extinct during earth history is about one billion. Each species is unique, a result of irreversible evolutionary processes. The giant panda is as unique as is any species of termite, the long-eared owl, or *Homo sapiens*. The enormous variety of species is one remarkable charasteristic of life on earth. The biologist must cope with this variety and is compelled to find a reasonable system of order. No other discipline of the (natural) sciences is confronted with such a tremendous multiformity, a consideration that underlines the autonomy of biology (see Wuketits 1997, 2002).

Young biology students are attracted to genetics and molecular biology, and the applications of biotechnology, particularly genetic engineering. They tend to forget the importance of knowing organisms. This is also due to the fact that in the last decades our institutions of higher education have dramatically changed their curricula at the expense of disciplines that deal with the diversity of life: systematics, taxonomy, and morphology. According to my own teaching experience, many biology students, even at at the postgraduate level, are suprisingly ignorant about biodiversity and have poor knowledge of species. They tend to believe that doing systematics and taxonomy resembles stamp collecting rather than practicing serious science.

Mayr was trained as a biologist long before the "molecular revolution" of the 1950s, and his scientific biography reads as the biography of a "classical" naturalist. He first specialized in ornithology and did extraordinary work in avian systematics. He later proceeded to general questions of systematics and evolution (see Bock 1994). His expertise in systematics and taxonomy is undisputed. His views on systematic zoology are laid down in Mayr (1969); for him systematics has always played and still plays an important role in evolutionary biology. Young biologists can learn from Ernst Mayr: a prolific systematist and taxonomist of birds who early in his scientific career got acquainted with the tremendous diversity of life on earth and soon got attracted by general questions of biology, its history and philosophy.

EVOLUTION AND TELEOLOGY

As previously mentioned, the quest for purpose plays a major role in biology, but not so in the physical sciences or in chemistry. An antelope's leg, the neck of a giraffe, the structure of the leaf of a green plant, the eye of an octopus are examples of special adaptations that serve particular purposes. These purposes, however, are to be explained in terms of evolution by natural selection:

> The hand of man, the wings of birds, the structure and behavior of kidneys, the mating displays of peacocks are examples ... In general, those features and behaviors that are considered adaptations are explained teleogically. This is simply because adaptations are features that come about by natural selection. Among alternative genetic variants that may arise by mutation or recombination, the ones that become established in a population are those that contribute more to the reproductive success of their carriers. The effects on reproductive success are usually mediated by some function or property. Wings and hands acquired their present configuration through long-term accumulation of genetic variants adaptive to their carriers (F.J. Ayala in Dobzhansky *et al*. 1977, p. 499).

No surprise that teleological explanations have been postulated as a special type of (biological) explanations. They have challenged philosophers of biology, so that nowadays treatises on the philosophy of biology typically include a chapter on the subject (see Hull 1974; Rosenberg 1985; Sattler 1986; Wuketits 1982).

Living systems are the only natural systems that exhibit teleological structures and functions. Teleological explanations are considered "appropriate to describe, and account for the existence of, teleological systems and the directively organizd structures, mechanisms and patterns of behavior which these systems exhibit" (Ayala 1968, 1972). However, among contemporary biologists or philosophers of biology, one will hardly find any believers in a universal or cosmic teleology. Teleological explanations are not meant to contradict causal explanations, but "are fully compatible with causal accounts" (Ayala 1970, 1999). The distinction between "teleological" and "teleonomic" has proved very useful. Mayr (1974, 1988, 1997, and in some other writings) has stated why this distinction is important. (He also uses the term "teleomatic" to characterize processes based on physical laws and not to be confused with teleology or teleonomy. A falling tree branch, for instance, finally reaches the ground just because of the law of gravitation; this process does not include any program or even goal-seeking behavior.)

"Teleology" has, since Aristotle, pointed to goal-intended processes or actions. It presupposes final goals or purposes and a kind of "conscious actor." In the modern (natural) sciences it has a bad reputation, which is why some thought it reasonable to introduce the term "teleonomy," a term coined by Pittendrigh (1958). Teleonomic processes are phenomena such as individual development or "acts" of behavior, which are not present for any "higher purposes," but are simply based on programs that are the outcome of evolution by natural selection. There is nothing mysterious about teleonomy. It refers to the fact that "natural selection 'breeds' structures which fulfil particularly well a certain survival function" (Lorenz 1977, p. 22). The same is, of course, also true of behavioral traits. A biologist who states that a cat's curved, pointed claws serve the purpose of catching mice, she is not at all implying conscious goal-intended processes or a Creator designing claws and other structures for special purposes. Rather, the biologist would argue that, under particular constraints, this type of claws has been favored by natural selection.

Teleological explanations, then, are not an indication of the belief in any end-intended results (organs or behavioral traits). As Ayala (1968) states: "The presence of organs, processes and patterns of behavior can be explained teleologically by exhibiting their contribution to the reproductive fitness of the organisms in which they occur. This need not imply that reproductive fitness is a consciously intended goal." The key to an understanding of teleology, (in the sense of teleonomy) is evolution by natural selection that excludes a belief in "final causes." Teleological (teleonomic) processes in the living world are nothing unnatural, but they are something special in nature, in that they are inherent in living organisms. The invocation of universal (cosmic) teleology is not only unnecessary, but completely obsolete.

THIS IS BIOLOGY

Biology is an autonomous science. It is irreducible to physics (and chemistry), because its objects (organisms) cannot be reduced to objects of the inanimate world. Though compatible with elementary physical (and chemical) laws, living systems require explanations and theories going beyond physics (and chemistry). In *This is Biology*, Mayr (1997) has established the science of life firmly as a science for itself, so to speak, and addressed the fundamental types of questions in biology: "What?", the study of biodiversity; "How?", the study of individual development; and "Why?", the study of the evolution of organisms. The book includes chapters on grand questions like "What is life?", "What is science?", "What is the place of humans in evolution?", and "Are there evolutionary explanations for ethics?".

This is Biology is lucid, trenchant and, maybe, annoying for some philosophers of biology or even biologists who may think that Mayr is dogmatic and ignorant of "other" perspectives on the science of life. Why should he have "the last word" about biology? As a reviewer of the book

(Sismondo 2000, p. 106) states, "*This is Biology* is also 'This is Ernst Mayr'. Because he has seen more of biology in the twentieth century than anybody else, and has put considerable effort into understanding and chronicling the history of biology."

It has to be stressed that Mayr's interest in the history of his discipline goes back to the 1930s, and that parallel to his work in ornithology, systematics, and evolutionary biology he has always been concerned with historical and philosophical questions in the science of life (although, he only published comprehensive works on these questions as an octo- and nonagenarian). His work reminds us of the importance of a general and synthetic history of biology going beyond "more detailed, localized and chronologically confined studies" (Burckhardt 1994, p. 368). It is this broad perspective that has enabled Mayr to reconstruct the history of biology not as a linear process, but as a history of ideas and controversies. His profound knowledge of scientific reasoning and theorizing has given him the ability to see so clearly the special status of biology in the natural sciences. *This is Biology* is Mayr's attempt to give a broad picture of biology as a science and of philosophical issues related to it. The book also reflects his fear that philosophers often have not understood, or have misunderstood, biology, although this is certainly not true in the case of some of them. "It is a tribute to his wide interests and his intellectual energy that in his tenth decade he continues to read recent work in the philosophy and history of science" (Sismondo 2000, pp. 103-104).

From *This Is Biology* and other writings, one understands that biology is to be considered an autonomous science mainly for the following reasons:

(1) It deals with historical objects, organisms, that can be fully understood only if one reconstructs their history, *i.e.*, their evolution.
(2) It has to cope with an enormous diversity (millions of species), which also can only be understood on evolutionary grounds.
(3) Its objects, living organisms and their parts, are unique; each species is unique, each individual is unique, each cell is unique, etc.
(4) It has to answer the question "What for?" and deals with teleological aspects.

Hence it follows that

(1) biology is, regarding at least some of its subdisciplines, a historical science;
(2) biology has to classify and systematize the enormous variety of its objects;
(3) many biological laws and principles are different from physical ones, and

(4) biology requires a special type of explanations, *i.e.*, teleological explanations.

Mayr has always combated typological thinking ("essentialism") which has dominated Western philosophy for more then two thousand years and has influenced our thinking in many other areas (including biology). More than once he has stressed that what counts is not the "type" (in Plato's sense), but variation and variability. A passionate Darwinist and brilliant interpreter of Darwin's ideas, Mayr (2000, p. 82) states:

> Darwin completely rejected typological thinking and introduced instead the entirely different concept now called population thinking. All groupings of living organisms, including humanity, are populations that consist of uniquely different individuals. No two of the six billion humans are the same. Populations vary not by their essences but only by means of statistical differences. By rejecting the constancy of populations, Darwin helped to introduce history into scientific thinking and to promote a distinctly new approach to explanatory interpretation of science.

Mayr, thus, helped to deepen and promote our insight into the meaning of history in science and to understand what the science of life really is. He has drawn most important conclusions from population thinking: Once we have grasped that variations, and not types, are real, we will no longer be open to racism. Hence, biology can positively shape our political world view. For brevity's sake I cannot go deeper here into this matter, but I wanted to remind the reader of the compass of Mayr's thinking about biology and its implications.

It is, finally, worth mentioning that Mayr has always strongly believed in chance in evolution, and in (his) personal life. "My life," he said on the occasion of his ninetieth birthday, "has been a series of accidents, just as in Darwinian evolution" (Mayr 1994, p. 329). This is not to be understood just as a personal testimony. Mayr's conviction is, to put it briefly, that physics deals with deterministic laws and is itself a deterministic science, so to speak, while biology is not. I do not want to analyze here the status of physics with regard to determinism, nor I purport that Mayr is entirely right in his evaluation of physics. Nevertheless, and this I consider more important, Mayr has understood very well that (biological) evolution is not a deterministic process, that chance plays a major role in all evolutionary processes, but that natural selection constrains random events and gives evolution some direction (see also Mayr 1962). A posteriori, this direction may seem to be goal-intended and, indeed, has been frequently misunderstood as an indication of teleology in the classical sense.

So, what is biology? It is a (natural) science, this is clear and trivial. But it has to answer questions and explain phenomena that go beyond physics and chemistry. Also, what should never be forgotten, it offers explanations of the origin and evolution of our own species, its particular evolutionary pathways and its present situation. Francis Crick once said: "The ultimate aim of the modern movement in biology is in fact to explain *all* biology in terms of physics and chemistry" (quoted after Chedd 1972, p. 6). I do not know, whether Ernst Mayr has ever read this particular statement; if he read it, he surely would disagree. There cannot be a bigger contrast between this statement and his understanding of biology. Mayr, the naturalist, has had a predilection for the "biology of whole organisms," like his fellow combatant in the formation of the Synthetic Theory of evolution, George G. Simpson, who remarked that "to understand organisms one must explain their organization" (Simpson 1962, p. 40). In other words: knowing genes and molecules is not enough.

CONCLUSION

"Biology must retain the courage of its own insights into living nature; for, after all, organisms are not just heaps of molecules" (Weiss 1969, p. 400). Mayr could have written down this statement. Trained as a naturalist, a gifted observer of animals and a brilliant theoretician, he has never accepted the prevalence of molecular biology. It would be wrong and unfair to say that this is just a question of generation. Mayr was 49 years old when the double helix was discoverd in 1953. One might speculate that a scientist at this age has achieved a more or less "closed" world view. But Mayr has always been eager to learn something new and, as we all know, has always, even in his nineties, followed new developments in biology and tried to integrate new data and theories into his own world picture. He has been accused of being dogmatic, but even his critics admit that because of his experience in many fields of biology and his intuition for history and philosophy he is quite well prepared to state what biology really is.

Biology is a most fascinating science, and to philosophize about biology is fascinating as well. What we learn from Ernst Mayr is that biology requires its own philosophy and that doing philosophy of biology helps us better to understand philosophy of science in general. Ernst Mayr's writings may encourage younger biology students to reflect on philosophy, science, and biology and to find their own place in academic science (and philosophy). One should not overlook Mayr's role as a science educator. Particularly, his last three or four books, among them *This is Biology* (1997) and *What Evolution Is* (2001), offer serious reflections on how biology and, generally, science can and should be done. These books show the importance of philosophical issues and may encourage biologists to look, at least from time to time, beyond the problems of their everyday research. Taking Ernst Mayr seriously, after all, means to be concerned with the place and role of biology in our culture—and with the particular role of organisms (including humans) in nature, an issue that gives biology a special task among the (natural) sciences.

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