An appreciation of biologist Ernst Mayr (1904-2005)

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3 May 2005

Ernst Mayr, arguably the preeminent biologist of the twentieth century, died on February 3, succumbing after a short illness at the age of 100. Mayr was the last survivor of a generation of renowned natural scientists that included the likes of Julian Huxley, George Gaylord Simpson, Theodocious Dobzhansky, J.B.S. Haldane, G.L. Stebbins and Hermann Muller, all of whom worked to establish Darwinian evolution as the cornerstone theory of biology.

Mayr's contributions to the science of biology, during the course of his remarkable life, are manifold. He will be remembered primarily for his role in the elaboration of what has become known as the Synthetic Theory of Evolution—the syntheses of the Darwinian ideas of evolution through natural selection and the common descent of all living organisms from extinct forms, with the science of genetics—from the groundbreaking work of Gregor Mendel in the nineteenth century to the revealing of the DNA double helix by Rosalind Franklin, James Watson and Francis Crick in the early 1950s.

In addition, Mayr is chiefly credited with formulating the "biological species concept," the notion that species are not simply defined by a static compilation of common physical characteristics, but are dynamic populations of interbreeding organisms interacting with other species in an environment while remaining reproductively isolated, that is, they are prevented either geographically or behaviorally from breeding with other closely related groups.

The biological species concept both incorporated and enriched Darwin's revolutionary ideas regarding the introduction of species and their geographical distribution. Darwin had sought causal explanations (ability of a species to disperse, e.g.) for the appearance of closely related species in unexpected locations, striking a blow against the creationist notion that species are found where they were originally "created." The subsequent work of Mayr with birds, and that of G.G. Simpson with mammals, has greatly enhanced our understanding of the geographical distribution of species.

Mayr was a tireless proponent of "population thinking," a profound idea that plumbs the depths of the contradictions inherent in concepts such as "species" and "population." He emphasized that while the characteristics of populations are shaped and altered by natural selection, each individual member of that population is unique. Early on, Mayr rejected "essentialism," an idealist conception that posited the existence of "typical" individuals within any given population, a viewpoint that, with the rediscovery of Mendel's laws of inheritance at the turn of the last century, made a considerable comeback at the expense of Darwinism. Mayr pointed out that the racialist notions that were widely held during that period were thoroughly essentialist, in that they accepted as given the existence of "average" or typical racial types.

Mayr, on the other hand, favored the viewpoint that focused on the fact that no two individuals making up a species (or a "race" for that matter) are alike. For Mayr, as for Darwin, it was the uniqueness of every member of a population that served as the fuel for natural selection, providing the impetus for the evolution of entirely new types of organisms. Once the genetic mechanism for the production of continuous diversity was understood, the profundity of Darwin's original ideas were reestablished and enriched in the form of the new synthesis.

Ernst Mayr was born in Germany, in the town of Kempten, Bavaria in 1904. The offspring of a long line of doctors, Mayr chose instead to concentrate his considerable intellectual abilities in the field of zoology, with a special interest in ornithology. At that time, Germany was still a major center of evolutionary biology, a tradition that owed to the work during the latter half of the nineteenth century of such notables as Ernst Haeckel and August Weismann.

Haeckel, who had made major contributions in zoology, as well as in originating some of the familiar terms in biology (ecology, e.g.), is chiefly remembered for advancing his famous "Biogenetic Law," which held that the developing embryo of an organism (ontogeny) was a recapitulation of the evolutionary history of that organism (phylogeny). Weismann was a pioneer in the science of genetics, who, among his major accomplishments, established the role of sex in promoting variation within a species, and determined that gametes (sex cells) have the haploid number (half the normal or diploid number) of chromosomes.

Mayr's attraction to birds brought him in contact with Erwin Stresemann, who was the curator of birds at the University of Berlin Museum of Natural History. Stresemann became his PhD advisor, and Mayr attained this advanced degree at the age of 21. Due to his astonishing longevity, as well as his European origin, Mayr was in certain essential respects a living link between nineteenth and twentieth century biology, in that while he was certainly comfortable with the quantitative aspects of the biological sciences devoted to genetics and molecular biology, he held qualitative methodologies, the use of observation and comparison to gain new insights, in high regard. It is not surprising, then, that following his studies in Berlin, Mayr, like countless naturalists before him, embarked on an expedition of discovery to the Solomon Islands and New Guinea, to collect specimens for Lord Rothschild's museum at Tring, Hertfordshire, in England, and for the American Museum of Natural History in New York.

In 1931, Mayr emigrated to New York, and took a job at the museum as a curator of birds, in particular of the 280,000 bird specimens of the Rothschild collection that were donated to the museum shortly after Mayr's arrival. In an interview that marked his 100th birthday, Mayr declared: "I was very anti-Nazi, so there was no way I could return [to Germany]" (2004). In 1953, Mayr left the museum to take a position as the Alexander Agassiz professor of zoology at Harvard. Mayr remained at Harvard for the rest of his life, and was active until his final illness.

Mayr was the author or co-author of more than 20 books—among them *Systematics and the Origin of Species* (1942), *Animal Species and Evolution* (1963), *One Long Argument: Population, Species and Evolution*, *What Evolution Is* (2001), his seminal work, *The Growth of Biological Thought* (1982) and *Toward a New Philosophy of Biology*

(1988). His final work, titled *What Makes Biology Unique*, was published shortly after his 100th birthday. He also founded the journal *Evolution* in 1947, and was a contributor to more than 600 scientific papers. Mayr's spouse of 55 years, Margarete (Gretel) Simon, died in 1990.

If one were to characterize the trajectory of Mayr's development as a scientist, it would be that he was primarily a naturalist turned theoretician. He was not a popularizer in the manner of his Harvard colleague, the late Stephen Jay Gould, but his theoretical acumen (in this writer's opinion) ran deeper. In fact, Mayr was critical of the late paleontologist's punctuated equilibrium hypothesis as an explanation of the evolutionary process for its overemphasis on the role of saltation (leaps). Mayr didn't completely reject Gould's theory, but explained that it did not contradict Darwinian gradualism, because such sudden bursts of evolutionary development are populational phenomena, that is, they occur at the species level. Thus, a sudden evolutionary spurt is always subsumed within the overall processes of evolution, which are for the most part gradual. Mayr took pains to point out that these accelerated evolutionary events appear saltational only when compared with the vastness of the geological time scale.

Various theories of saltation as descriptors of the "sudden" appearance of new types of organisms have come and gone over the centuries, having their roots in the catastrophism (multiple creations) of the renowned comparative anatomist Georges Cuvier (1769-1832), who tried to explain the existence of extinct animals (dinosaurs, e.g.), and fit them into some kind of schema compatible with Biblical creation.

Even later saltationist theories for the evolution of species or whole groups of organisms could be interpreted as implying a kind of special creation, opening the door to a religious interpretation of the complexities of the natural world. Mayr was certainly cognizant of this danger as his well-known discourse on the nature of chance and selection, what he termed the "adaptationist dilemma," attests. In his book, *Toward a New Philosophy of Biology* (1988), Mayr is critical of Gould and Richard Lewontin for their attack on the notion that the development of adaptations as a result of natural selection is anything but the result of stochastic (chance) processes, therefore rendering the term adaptation obsolete, and casting a pall over natural selection, the foundation concept of Darwinism.

Gould went so far as to call the notion of a process of adaptation a "Panglossian paradigm" (after Voltaire's character in *Candide)*, a futile search for perfection in the evolutionary process.

Mayr's reply is a clinic on the dialectical approach to a complex and seemingly contradictory process. He wrote: "When asked whether or not the adaptationist program is a legitimate scientific approach, one must realize that the method of evolutionary biology is in some ways quite different from that of the physical sciences. Although evolutionary phenomena are subject to universal laws, as are most phenomena in the physical sciences, the explanation of a particular evolutionary phenomenon can be given only as a 'historical narrative.' Consequently, when one attempts to explain the features of something that is the product of evolution, one must attempt to reconstruct the evolutionary history of this feature."

He continued by explaining that when one rejects all manner of teleological explanations for the adaptation of species to their changing environments one is left with two unified, but seemingly contradictory propositions—chance and selection forces. "The identification of these two factors as the principal causes of evolutionary change by no means completed the task for the evolutionist. As is the case with most scientific problems, this initial solution represented only the first orientation. For completion it requires a second stage, a fine-grained analysis of these two factors: What are the respective roles of chance and or natural selection, and how can this be analyzed?" (1988)

Mayr's life-long interest in the fundamental questions that continue to animate the biological sciences, combined with his exceptional longevity as a working and thinking scientist, engendered in him a profound appreciation of its history. In particular, he stressed the importance of a study of the history of scientific concepts (natural selection, e.g.). He wrote: "Preoccupation with this sort of conceptual history of science is sometimes belittled as a hobby of retired scientists. Such an attitude ignores the manifold contributions which this branch of scholarship makes" (1982). He stated further: "One can take almost any advance, either in evolutionary biology or in systematics, and show that it did not depend as much on discoveries as on the introduction of new concepts.... Those are not far wrong who insist that the progress of science consists principally in the progress of scientific concepts" (1982).

Mayr frequently commented on what he perceived to be the sharp dichotomy between experimental and theoretical science, and the growing inclination toward reductionism in biology. He would bristle against the accusation, often made by physicists and philosophers, that biology was not "hard" science. An interesting byproduct of this common misconception, one that Mayr noted in a recent interview, was that there continues to be no Nobel Prize awarded in biology.

Mayr championed the notion that the governing concepts of the science of biology were not simply reducible to mathematical formulae and the timeless laws of physics. By this he did not mean that biological processes existed outside the realm of the laws of chemistry and physics, or that many aspects of the living world did not lend themselves to quantification, but that living processes could not be entirely explained or even understood from those standpoints.

Mayr explained that in previous centuries natural scientists, under pressure to be able to draw conclusions from their working hypotheses that were reducible to mathematical formulae and the laws of physics, either succumbed to that pressure and presented purely mechanical explanations for living processes, or sought vitalist (those who claim that the property of being alive is sparked by an outside force) and even religious explanations for the processes being studied.

In referring to the higher levels of complexity of living systems, Mayr stressed their duality, that is, each organism is at once an expression of its genotype, the historically developed genetic code for the synthesis of proteins, and its phenotype, the unique physical appearance of each individual of a species; the product of the complex interplay of physiological, embryological and ecological processes. He placed particular emphasis on two properties unique to living systems, teleonomy (goal-directed processes) and "emergentism," the tendency for the evolution of "emergent properties," a notion that reaches beyond the idea that the *whole is greater than the sum of its parts*.

Regarding the latter, he wrote in *The Growth of Biological Thought*: "Systems almost always have the peculiarity that the characteristics of the whole cannot (not even in theory) be deduced from the most complete knowledge of the components, taken separately or in other partial combinations. This appearance of new characteristics in wholes has been designated as emergence" (1982).

As a prime example, he cited the work to uncover the importance of DNA for the science of genetics. "The discovery of the double helix of DNA and of its code was a breakthrough of the first order.... There is nothing in the inanimate world that has a genetic program which stores information with a history of three thousand million years! At the same time, this purely materialistic explanation elucidates many of the phenomena which the vitalists had claimed could not be explained chemically or physically. To be sure, it is still a physicalist explanation, but one infinitely more sophisticated than the gross mechanistic explanations of earlier centuries" (1982).

An emergent property, then, is something unanticipated—the evolution of new behaviors, or new adaptations (lungs, language, abstract thought, e.g.), that has unforeseen implications that propel a species or a group of

organisms in an entirely new direction. It should be noted that Mayr considered the concept of emergentism to be philosophically "entirely materialistic."

Not surprisingly, Mayr was a lifelong atheist and a staunch opponent of the ongoing attack on evolution by the motley assemblage of religious zealots, creationists and "intelligent design" advocates. In 1991, he commented in an interview in the *Harvard Gazette*: "I'm an old-time fighter for Darwinism. I say, 'Please tell me what's wrong with Darwinism. I can't see anything wrong with Darwinism." For Mayr, Darwin's contribution to mankind's knowledge of the natural world was revolutionary. During an interview on his 93rd birthday, Mayr commented that one of "Darwin's great contributions was that he replaced theological, or supernatural, science with secular science. Laplace had already done this some 50 years earlier when he explained the whole world to Napoleon. After his explanation, Napoleon replied, 'Where is God in your theory?' And Laplace answered, 'I don't need that hypothesis.'

"Darwin's explanation that all things have a natural cause made the belief in a creatively superior mind quite unnecessary. He created a secular world, more so than anyone before him. Certainly many forces were verging in that same direction, but Darwin's work was the crashing arrival of this idea and from that point on the secular viewpoint of the world became virtually universal" (2005).

In the introduction to his *The Growth of Biological Thought*, Mayr wrote: "A well-known Soviet theoretician of Marxism once referred to my writings as 'pure dialectical materialism.' I am not a Marxist and I do not know the latest definition of dialectical materialism, but I do admit that I share some of Engels' anti-reductionist views, as stated in his *Anti-Duhring*, and that I am greatly attracted to Hegel's scheme of thesis-anti-thesis-synthesis." For the most part, Mayr can be classified as a consistent materialist. However, his outlook stops short of embracing historical materialism, falling victim to the widely promulgated viewpoint that history consists of a series of narratives, rather than the workings of historical laws.

Mayr was one of the outstanding figures of twentieth century science—brilliant and passionate, with an encyclopedic knowledge of science, history and philosophy. His contributions to an understanding of the big questions in biology, not to mention those animating science in general, have been enormous. One can only anticipate that others, in the face of the continuing assault on the scientific world outlook, will take up the defense and further illumination of the fundamental theoretical conquests of biology with equal vigor and erudition.

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