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Author(s): Paul Thagard
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Against Evolutionary Epistemology[1]

Paul Thagard

University of Michigan-Dearborn

By "evolutionary epistemology" I mean Darwinian models of the growth of scientific knowledge. Such models rely on analogies between the development of biological species and the development of scientific theories. Recent proponents of evolutionary epistemology include the psychologist Donald Campbell (1974a), the sociobiologist Richard Dawkins (1976), and philosophers of science Karl Popper (1972), Stephen Toulmin (1972), and Robert Ackerman (1970). I shall argue that the similarities between biological and scientific development are superficial, and that clear examination of the history of science shows the need for a non-Darwinian approach to historical epistemology.[2]

The neo-Darwinian model of species evolution consists of Darwin's theory of natural selection synthesized with twentieth century genetic theory. The central ingredients of the neo-Darwinian model are variation, selection and transmission.[3] Genetic variations occur within a population as the result of mutations and mixed combinations of genetic material. Individuals are engaged in a struggle for survival based on scarcity of food, territory, and mating partners. Hence individuals whom variation endows with traits which provide some sort of ecological advantage will be more likely to survive and reproduce. Their valuable traits will be genetically transmitted to their offspring.

Evolutionary epistemology notices that variation, selection and transmission are also features of the growth of scientific knowledge. Scientists generate theories, hypotheses, and concepts; only a few of these _variations_ are judged to be advances over existing views, and these are _selected_; the selected theories and concepts are transmitted to other scientists through journals, textbooks, and other pedagogic measures. The analogies between the development of species and the development of knowledge are indeed striking, but only at this superficial level. I shall try to show that variation, selection, and transmission of scientific theories differ significantly from their counterparts in the evolution of species.

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First consider variation. The units of variation in species are genes, with variation produced by errors in the process by which genes are replicated. Since the changes in genes are generally independent of the individual's environmental pressures, genetic variation is often said to be random. A better characterization is that of Campbell, who discusses blind variation (Campbell 1974a, p. 422). He outlines three important features of blindness: variations emitted are independent of the environmental conditions of the occasion of their utterance; the occurrence of trials individually is not correlated with what would be a solution to the environmental problem which the individual faces; and variations to incorrect trials are not corrections of previous unsuccessful variations.

It is immediately obvious that the development of new theories, hypotheses and concepts in science is not blind in any of these respects. One does not have to suppose there is some algorithmic logic of discovery to see that when scientists arrive at new ideas they usually do so as the result of concern with specific problems. Hence unlike biological variation, conceptual variation is dependent on environmental conditions. Whereas genetic variation in organisms is not induced by the environmental conditions in which the individual is struggling to survive, scientific innovations are designed by their creators to solve recognized problems; they therefore are correlated with a solution to a problem, in precisely the way in which Campbell says blind variations are not. It is also common for scientists to seek new hypotheses which will correct errors in their previous trials, as in Kepler's famous efforts to discover a formula to describe the orbit of Mars (Hanson 1958, pp. 733ff.). Thus the generation of the units of scientific variation does not have any of the three features of blindness which Campbell describes as characteristic of evolutionary variation.

Let us examine in some detail the process by which new theories are developed.[4] The non-randomness of theory generation has been most interestingly discussed by C.S. Peirce and N.R. Hanson. Peirce describes a form of inference called "abduction" which yields explanatory hypotheses (Peirce 1931-1958, Vol. 2, para. 776). Faced with a puzzling phenomenon, we naturally seek a hypothesis which would explain it. The form of abductive inference can be represented as follows:

(S1) Phenomenon P is puzzling.
Hypothesis H would explain P.
∴ H is plausible, and should be subjected to test.

Arguments for the existence of abduction are of two kinds. First, as a matter of historical fact, it seems that abduction is often used by scientists. Besides the example of Kepler already mentioned, we could cite the developments leading up to Darwin's discovery of the theory of natural selection. He describes being struck by the character of South American fossils and the geographical distribution of species there and on the Galapagos archipelego, and states that these facts are the "origin. . . of all my views." (Darwin 1959, p. 7; cf.,Darwin 1887, p. 42). These phenomena led him to believe that species had become modified, and after fortuitously reading Malthus he conceived how a struggle for survival could lead to natural selection. But the theory of natural selection was on no account a blind variation, since it served to account for phenomena which Darwin had been worrying about for years.

The second argument for the existence of abduction is that without some such sort of reasoning scientific growth would be impossible. For there would be no way of winnowing the unlimited set of possible hypotheses which would have to be considered and tested if hypotheses were generated randomly or blindly (Peirce 1931-58, vol. 5, para. 591; cf. Rescher 1978, ch. 3). If scientific theories and concepts were developed randomly, we would rarely come up with good ones, since the number of possible hypotheses is unmanageably great. Peirce hypothesized the existence in humans of an abductive instinct which innately aids our construction of hypotheses. But regardless of the existence of any special instinct, it is easy to see that a process wherein scientists intentionally strive to come up with hypotheses with certain characteristics will arrive at such hypotheses much more quickly than scientists generating hypotheses blindly. As Rescher notes (1978, p. 56), evolutionary epistemology is unable to account for both the existence and the <u>rate</u> of scientific progress.

N.R. Hanson (1961) discusses a form of reasoning akin to Peirce's abduction, which involves the conclusion that a sought for hypothesis is likely to be of a certain <u>kind</u>. The form of this reasoning is:

(S2) Phenomenon P is puzzling.
Similar phenomena have been explained by hypotheses of kind K.
∴ It is likely that the hypothesis we need to explain P will be of kind K.

Narrowing our search to certain kinds of hypotheses is obviously much more economical than blindly developing a huge variety of hypotheses. That Darwin arrived at a theory in which selection was a crucial concept was not accidental: he had earlier been struck by similarities between modifications in domestic species produced by artificial selection. Kepler's discovery was preceded by his conviction that the orbit of Mars was probably some sort of ellipse. Thus arguments that hypotheses are likely to be of a certain kind are a useful preliminary to the abductive inference that a particular hypothesis is worthy of investigation.

As Toulmin notes (1972, p. 337f.), in the history of science variation and selection are "coupled", in the sense that the factors responsible for selection are related to those responsible for the original generation of variants. Scientists strive to come up with theories which will survive the selection process. The criteria used in looking for a new theory in accord with (S1) and (S2) above are also relevant to arguments that a theory be accepted: at both levels, we want a theory which explains puzzling facts and which has analogies with accepted theories (Thagard 1978a). In contrast, species variation and selection are "uncoupled": the factors which produce genetic modification are unrelated to the environmental struggle for survival, except in special cases where the environmental threat is unusually mutagenic. The coupling of variation and selection for scientific theories makes theory choice a much more efficient procedure. If variation were blind, we would be faced with the necessity of choosing among an unmanageably large number of theories. Instead, the intentional, quasi-logical process by which hypotheses are generated narrows the range of candidates which must be considered for selection. That theoretical variation and selection are coupled is a serious flaw in the Darwinian model of the growth of knowledge.

Another possible objection to evolutionary epistemology concerns the magnitude of the advance which variations achieve over their predecessors. It might be said that variations in theories and concepts can involve substantial leaps, whereas in neo-Darwinian biology the development of species is gradualistic. However, I shall not press this point, because of the difficulty of assessing the relative size of leaps in such disparate spheres. Perhaps relativity theory does represent a "revolutionary" improvement over Newtonian mechanics, of a magnitude unparallelled in current biology which eschews saltations. But critical comparison is prevented by the indeterminacy of criteria for estimating magnitude of change and for distinguishing between revolution and evolution.

A clearer difference between biological and scientific development is that the <u>rate</u> of theoretical variation seems to be partly dependent on the <u>degree of</u> threat to existing theories. In Kuhnian terminology (Kuhn 1970), there is more likely to be a proliferation of new concepts and paradigms when a field is in a state of crisis. The rate of biological variation is not similarly sensitive to degree of environmental pressure on organisms.

This completes my argument that theoretical variation is substantially different from biological variation. The main differences have concerned blindness, direction and rate of variation, and coupledness of variation and selection. It is ironic that the great merit of Darwin's theory - removing intentional design from the account of natural development - is precisely the great flaw in evolutionary epistemology. The relevant difference between genes and theories is that theories have people trying to make them better. Abstraction from the aim of scientists to arrive at progressively better explanations of phenomena unavoidably distorts our picture of the growth of science. I shall now argue that this is as true of the <u>selection</u> of theories as it is of the origin of theories.

The differences between epistemological and biological selection arise from the fact that theory selection is performed by intentional agents working with a set of criteria, whereas natural selection is the result of differential survival rates of the organisms bearing adaptive genes. Nature selects, but not in accord with any general standards. Nature is thoroughly pragmatic, favoring any mutation that works in a given environment. Since there is such an enormous range of environments to which organisms have adapted, we can have no global notion of what it is for an organism to be fit. Fitness is not inherently a property of an organism, but is a function of the extent to which an organism is adapted to a specific environment.

In contrast, theory and concept selection occurs in the context of a community of scientists with definite aims. These aims include finding solutions to problems, explaining facts, achieving simplicity, making accurate predictions, and so on (Kuhn 1977, ch. 13; Laudan 1977; Thagard 1978a). Perhaps at different times different aims are paramount, so that there may be inconstancy and even subjectivity in the application of criteria for theory choice. Certainly the application of such criteria is extremely complex, and there is nothing approaching an algorithm for determining which of competing theories deserves acceptance. Nevertheless, when scientists are advocating the adoption of a new theory, they appeal to some of a basic set of criteria according to which their theory is superior to alternatives. (See Thagard 1978a for illustrations.) Perhaps the criteria themselves have evolved, but since the seventeenth century there seems to me to have been agreement at the general level about what new theories should accomplish in explanation, problem solving and prediction, even if the application of these general aims in particular cases has been very controversial. But the controversy derives from the complexity of the set of criteria, not from any fundamental disagreement about the whole range of desiderata. Defense of this claim would take more space than is available here. If it is true, then selection of theories is strikingly different from the selection of genes. Survival of theories is the result of satisfaction of global criteria, criteria which apply over the whole range of science. But survival of genes is the result of satisfaction of local criteria, generated by a particular environment. Scientific communities are unlike natural environments in their ability to apply general standards.

Progress is the result of application of a relatively stable set of criteria. Progress is only progress with respect to some general set of aims, and results from continuous attempts to satisfy the members of the set in question. Since scientists do strive to develop and adopt theories which satisfy the aims of explanation and problem solving, we can speak of scientific progress. In contrast, there is no progress in biological evolution, since survival value is relative to a particular environment, and we have no general standards for progress among environments. We could perhaps say that evolution of homo sapiens is progressive given our environment and our extraordinary ability to adapt to it, but our species may well someday inhabit an environment to which so-called lower animals are much better adapted. A post-nuclear war environment saturated with radioactivity would render us less fit than many less vulnerable organisms. Biological progress might be identified with increase in complexity, control over the environment, or capacity for acquiring knowledge, but none of these is a universal trend in evolution. As G.G. Simpson summarizes (1967, p. 260): "Evolution is not invariably accompanied by progress as an essential feature." Hence the Darwinian model of development employed in evolutionary epistemology lacks a concept of progress essential in historical epistemology. (For further discussion, see Ayala 1974 and Goudge 1961 on biological progress; and Laudan 1977 on progress in science.)

Thus selection is a stumbling block to evolutionary epistemology with respect to the conscious application of general criteria and the achievement of progress. Let us now consider biological and epistemological transmission.

Modern genetic theory provides us with an account of how genes which increase the fitness of an organism are preserved and transmitted to the organism's offspring. Preservation and transmission of conceptual survivors is quite different. A beneficial gene is replicated in specific members of a population, but a successful theory is immediately distributed to most members of a scientific community. Preservation is by publication and pedagogy, not by any process resembling inheritance. Dissemination of successful theories is much more rapid than dissemination of beneficial genes. This is one of the reasons why conceptual development seems to be so much more rapid than biological development. (The others include the intentional aspect of theoretical variation, and the progressive aspect of theory selection, already discussed.) Thus at the level of transmission of units of variation, as well as at the levels of variation and selection, the growth of knowledge is very different from the evolution of species.

Even the <u>units</u> of variation and transmission have very different properties. Dawkins (1976) postulates "memes" as the conceptual replicating entities analogous to genes. But this postulation is gratuitous since we already have notions which describe the entities which develop in scientific and cultural change. These entities include theories, laws, data, concepts, world views, and so on. Talk of memes does nothing to overcome the immense problems of explicating the nature of theories, concepts and world views. We know very little in detail about the nature of these entities, although they are clearly more complex and interconnected than are genes. A historical epistemology which is faithful to the actual history of science will have to go beyond misleading biological analogies.

What should a model of historical epistemology look like? Two possible alternatives to a Darwinian account of the growth of knowledge can quickly be seen to be inadequate. A Lamarckian model is superficially attractive since theories are passed on like acquired characteristics and there is progress in science, as Lamarck thought there was in natural evolution (Lamarck 1809 Goudge 1961). But a Lamarckian view would neglect competition and selection of theories as well as the way that progress comes about, not through any internal purpose of theories, but through the aims and intentions of scientists. Hegel's dialectic has much to add to historical epistemology, since he was probably the first philosopher to emphasize the historical nature of knowledge, and his notion of <u>Aufheben</u> is useful in conceptualizing how new stages of thought both supersede and preserve their predecessors

(Hegel 1807). However Hegel seems to have made precisely the opposite mistake of evolutionary epistemologists who suppose that the inception of conceptual variants is blind: for Hegel, each stage of knowledge is the logically necessary result of the stage that preceded it. Variation is not blind, but, contra Hegel, it is not wholly determined by context either. There is a subjective, psychological element in discovery along with an aim-oriented, methodological element.

Hence we are not in a position to borrow a model for the growth of knowledge from Lamarck, Hegel, or Darwin. A model needs to be constructed. Our discussion has shown that it should take into account at least the following factors:

1) the intentional, abductive activity of scientists in initially arriving at new theories and concepts;

2) the selection of theories according to criteria which reflect general aims;

3) the achievement of progress by sustained application of criteria; and

4) the rapid transmission of selected theories in highly organized scientific communities.

Evolutionary epistemology fails because it neglects all of these factors.[5]

Notes

[1]I am grateful to Daniel Hausman and B. Holly Smith for suggestions.

[2]My critique of evolutionary epistemology is not concerned with the claim that human biology may be relevant to epistemology in more direct ways, for example in debates concerning innate ideas (cf., Campbell 1974a). Nor do I address the "genetic epistemology" of Piaget (1950). Another important issue omitted here concerns the extent to which the growth of scientific knowledge is not a purely internal matter but is conditioned by social forces.

[3]For summaries of the neo-Darwinian theory of evolution see Lewontin (1974), Simpson (1967), Patterson (1978), and Ruse (1973).

[4]For more extensive discussions of questions related to logical factors in discovery, see Thagard (1977), (1978b), (in press).

[5]Since writing this paper, I have become aware of Skagestad (1978) which covers some of the same ground.

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