NEW ARGUMENTS IN EVOLUTIONARY EPISTEMOLOGY

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METAPHYSICAL IMPLICATIONS OF DARWINISM?

Most implications of Darwinism are *antimetaphysical*. This is one of the reasons why Darwin's theory was resisted and why it is still regarded as a scientific *revolution*. To be sure, it was not Darwin's intention to become a revolutionary, but rather to solve interesting scientific problems. But his intention did not help him. In that respect, he may be likened to Nicolas Copernicus, Martin Luther, or Max Planck. Copernicus is characterized by Arthur Koestler as "the timid canon," and Planck by Helge Kragh as "the reluctant revolutionary" [1]. In a similar vein, Carl Friedrich von Weizsäcker, writing about Werner Heisenberg, submits "that only the conservative can be a revolutionary" [2].

Metaphysical or not, there is no doubt that Darwin's theory has *philosophical* consequences. Some of these consequences refer to epistemology. Darwin himself was well aware of this. Already in 1838, he wrote in his notebook M: "Plato says in his *Phaedo* that our 'necessary ideas' arise from the preexistence of the soul, are not derived from experience—read monkeys for pre-existence" [3]. Even in this short note it becomes plain that Darwin replaces a metaphysical concept, preexistence, by a biological one, monkeys as man's predecessors. Whether our ideas remain "necessary" in that move is another interesting problem.

Cognition takes place in our heads. From the signals flowing from our sense organs our brain builds a picture of the world up to a whole world view. We construe the world as three-dimensional, ordered and directed in time, regular, even structured by laws of nature, causally connected. We draw conclusions, proceed from past experiences to expectations with respect to future. With some of our constructions we are successful, with others we fail.

The principles by which we construct this world picture are not dictated by our sense organs or exclusively by external stimuli. How did they come into our head? This question is answered by *evolutionary epistemology*. I shall, first, recapitulate its main theses, and then characterize it as a

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naturalistic position and answer some typical objections. Later sections are devoted to more recent arguments, concerning language, realism and the theory of selection.

MAIN THESES OF EVOLUTIONARY EPISTEMOLOGY

Thinking and cognition are achievements of the human brain, and this brain originated in organic evolution. Our cognitive structures fit the world (at least partially) because phylogenetically they were formed in adaptation to the real world and because ontogenetically they have to tackle with the environment in every individual. George Gaylord Simpson (1902-1984) makes this point crudely but graphically: "The monkey who did not have a realistic perception of the tree branch he jumped for was soon a dead monkey—and therefore did not become one of our ancestors" [4]. We owe the fact that our spatial perception is relatively good to our predecessors living in trees with prehensile organs. We may also explain other cognitive achievements in a similar way.

Why, then, are our cognitive faculties not even better? The answer is simple enough: biological adaptation is never ideal—nor is our cognition. There is no evolutionary premium on perfection, but only on effectiveness. Decisive for evolutionary success is not pure quality, but a defendable cost-benefit relation. It is not essential to find the best possible solution but to be better than the competitors. Here we must think not only of inter-specific competition, but of intraspecific competition as well. Thus, evolutionary epistemology not only explains the achievements of our brain, but also its *failures*.

That section of the real world to which man is adapted in perception, experience and action may be called "mesocosm." It is a world of medium dimensions: medium distances and time periods, small velocities and forces, low complexity. Our intuition is adapted to this world of medium dimensions. Here our intuition is useful, here our spontaneous judgments are reliable, here we feel at home.

Whereas perception and experience are mesocosmically impregnated, scientific cognition may transcend the mesocosm. This happens in three directions: to the very small, the very large, and the very complicated [5]. As we know, intuition fails regularly there. Nobody can visualize the conditions of the quantum realm, relativity theory, or deterministic chaos. Moreover, we have to deal with complicated systems. In order to do so, we need working tools and thinking tools, instruction and training. The most important thinking tool is language. Other ladders leading beyond the mesocosm are algorithms, calculus, mathematics, computers.

EVOLUTIONARY NATURALISM

Evolutionary epistemology is *evolutionistically* oriented: It constitutively rests upon organic evolution. This has given evolutionary epistemology its name. The epithet "evolutionary" does not mean that all epistemological problems can or should be solved by reference to the evolution of the universe, of organisms, of man, of knowledge. However, it documents the claim that the evolutionary origin of our cognitive faculties plays an important role for epistemology, both explanatory and critical.

If Ludwig Wittgenstein claims in his *Tractatus*: "Darwin's theory has no more to do with philosophy than any other hypothesis in natural science" [6], it is something that we explicitly deny. To be sure, we must justify this denial with arguments, and this is done best by showing how evolution pertains to philosophy. It may happen that it solves old philosophical problems, that it poses (and even solves) new problems, and that it sheds new light on problems. Such triple claim is made by evolutionary epistemology.

It remains unclear, however, how general the concept of evolution is meant here. Do we speak of organic evolution, *i.e.*, the evolution of organisms, or do we also speak of the evolution of knowledge, maybe even of science? This ambiguity has been confusing. In this paper, I am speaking about the biological evolution of *cognitive faculties*. As an investigation of the development of science using evolutionary concepts in general, I prefer to call this enterprise *evolutionary philosophy of science* [7].

The general orientation of evolutionary epistemology is *naturalistic*. There is talk about naturalism in several areas: in theology, philosophy of science, ethics, art. In the present context, I take it to be a conception of natural philosophy and anthropology claiming that *all over the world there are no secrets*. Hence, it is distinguished by two traits: by its *universal claim* and by the *limitation of tools* being admitted for the description and explanation of the world [8].

Philosophical naturalism is both a conception and a program. In its programmatic sense it consists of at least four parts:

It calls for and charts a *cosmic view*, a "world view."

It assigns to *man* a definite place in the universe (which turns out to be rather modest after all).

It covers *all* capacities of man: language, knowledge, scientific investigation, moral action, esthetic judgment, even religious faith.

Under these premises it calls for and develops in particular:
– a naturalistic anthropology,
– a naturalistic epistemology,
– a naturalistic methodology of research,
– a naturalistic ethics,
– a naturalistic esthetics.

With respect to epistemological questions, W.V.O. Quine has formulated such a naturalistic program. Evolutionary epistemology tries to fill just this program. Occasionally, Quine himself brought in evolutionary points: “Natural selection, then, could explain why innate standards of resemblance have been according us and others animals better than random chances in anticipating the course of nature“ [9]. Or: “Creatures inveterately wrong in their inductions have a pathetic but praiseworthy tendency to die before reproducing their kind“ [10]. Quite analogously some people try to develop an evolutionary ethics. Generally, we may speak of an *evolutionary naturalism* [11].

Finally, evolutionary epistemology is *realistically* oriented. More precisely, it defends a *hypothetical realism*, characterized by the following:

Ontological realism: there is a real world independent (for its existence) of our consciousness, lawfully structured, and quasi-continuous.

Epistemological realism: this world is partially knowable and understandable by perception, thinking, and an intersubjective science.

Fallibilism: our knowledge about this world is hypothetical and always preliminary.

Against evolutionary epistemology numerous objections are raised [12]. I'll look at three of them.

FIRST OBJECTION: DOES THE CONCEPT OF TRUTH MAKE SENSE?

Hypothetical realism makes use of the *correspondence theory* of truth. In this theory a proposition is *true* if what it says corresponds with reality outside. But how do we get to know this reality, hence truth? There is no independent access to reality except for God. We humans cannot take this divine perspective, cannot know the world in itself, and therefore cannot assess truth in the sense of correspondence theory. So reads the objection.

As far as this objection is justified, it is directed against all kinds of epistemological realism (except perhaps the internal realism proposed by Hilary Putnam some years ago, which strictly speaking is no realism at all). In fact, we are not gods. The correspondence theory of truth does not supply a *criterion* of truth, but only a *definition* of truth. As epistemologists came to realize after 2 500 years of fruitless search and growing doubts, there are no satisfiable *sufficient* criteria for factual truth. What we have are *necessary* criteria like consistency, corroboration, coherence, or consensus, as exhibited by the different theories of truth. For the *definition* of truth all these theories rely, in the last analysis, on the correspondence concept. (Where this is not the case the concept of truth is, strictly speaking, superfluous.)

We might object that a God's eye perspective is an undue idealization. However, no theory of truth can do without such idealizations. Internal realism, for instance, regards as true what *at the end of all research* will be ascertained about the world. What is this, if not an idealization. Thus, realism and correspondence theory answer this last objection with a *tu-quoque* argument. Yes, there is an idealization, but all other theories of truth use similar devices.

SECOND OBJECTION: IS THE FIT OF OUR COGNITIVE STRUCTURES ASCERTAINABLE WITHOUT A VICIOUS CIRCLE?

Would we not have to know reality *independently* of our cognitive structures? This objection goes beyond the former because what is at stake now is not a definition of truth, but our knowledge about reality. Here, evolutionary epistemology makes a more ambitious claim.

Let's take an example: Physicists and physiologists disclose to us that our eyes are sensitive in precisely that section of the electromagnetic spectrum where—thanks to the optical window of the terrestrial atmosphere—radiation from the sun can pass through the air and reach the surface of the earth. How could they come to know this? Of course, even physics had to start in the mesocosm, but has definitely left it since. In doing that, physics has objectified its methods as much as its results and its theories. It does not talk about colors any more, but rather about frequencies, wavelengths, and energies. For the characterization and detection of radiation, it does *not* depend on the eye. And it finds electromagnetic radiation of all wavelengths. It is true, even expressions like "wavelength" or "sensitivity" could still be anthropomorphous. However, there is no doubt that, first, not all what in principle could exist does really exist; second, with our senses we can process only a *section* of what there is; and third, there is a very good *fit* between (what we call) daylight and the properties of our eye. We can detect this fit without being realists and without an explanation at hand. It is the fit thus established which is interpreted and explained by evolutionary epistemology. Not as pure chance nor as the work of a creator, but as the result of an *adaptive* process.

One could still object that what physicists describe is not the real world, but at best a projection, possibly a garbled one, and in the worst case nothing but a wild construction. It is true, we cannot strictly prove the truth, the correctness, the adequacy of our theories. But what on earth can be proved strictly? We cannot even disprove the solipsist claiming (or, in fact, being convicted) that there is nothing besides his present consciousness.

Where proofs are missing, good reasons might still be available. For ontological realism (there is a real world independent of our consciousness) and for epistemological realism (this world can be known at least in part and approximately) there are good arguments. For the suggestion, however, that scientific knowledge is nothing but a wild construction, there are *no* good arguments. And it is utterly unplausible that we should have biologically adapted to constructions which have been worked out by scientists during the last centuries.

Some constructivists think that organisms are indeed adapted, but not to an external world, but to survival. This is unbiological thinking. If there are no selective demands by the environment, then there can be no traits facilitating survival nor traits threatening it; in that case, any solution will do. But then, the concept of adaptation makes no sense at all.

Let's stick to it: We may sensibly talk of fits and adaptations; we may argue for them, but cannot prove them. Evolutionary epistemology is happy enough to explain these fits; that is, our cognitive achievements as well as our failures.

THIRD OBJECTION: HOW CAN COGNITIVE STRUCTURES BE ADAPTED TO AN ENVIRONMENT WHICH OF NECESSITY WOULD HAVE TO BE KNOWN TO THE ORGANISM BEFORE THIS ORGANISM MIGHT ADAPT TO IT?

If this objection were sound, there should be no eyes! For, how could eyes be adapted to terrestrial illumination if eyes were necessary *before* any light can be processed? But eyes *did* originate several times, and independently, at least forty times according to evolutionary biologists. And most eyes are perfectly well adapted to light. How could they originate? The answer is simple. Eyes originated as all things originate in evolution, namely by trial and error elimination, by blind variation and selective retention, by undirected mutations and gene recombinations and preferential reproduction of superior solutions. The evolution of the vertebrate eye—and that includes the human eye—can be reconstructed quite well. Similar considerations apply to all other sense organs, to all senses, to all perceptual achievements. There is no reason why they should not be applied to higher cognitive functions, as far as these are genetically conditioned.

For evolutionary origins and explanations it is essential, however, that an organ need not be perfect. The intermediate steps are evaluated selectively and must increase fitness. For this, it is not necessary that the later function be present and effective from the very beginning. Changes of function are possible and rather common. A trait may be built for a function that will be later replaced by another function. From fins arose arms and legs; feathers did not at first serve for flying, but for gliding, catching prey, keeping warm; the middle-ear ossicles are former jaw bones. Since the change of function is not saltatory it is indispensable that a trait has two or more functions at the same time [13].

For the eye such intermediate steps and multiple functions are well-known, because there are so many types of eyes. In other cases we must content ourselves with a scenario, that is with a sequence of steps showing how it might have happened. In some instances, intermediate stages and double functions are yet to be found.

LANGUAGE ABILITY, A HELPFUL ANALOGY

With respect to empirical tests, evolutionary epistemology faces two difficulties. On the one side, it asserts a strong genetic component for cognitive faculties. In this it takes sides with the classical *nativists* (who were mostly rationalists, as were Descartes and Leibnitz). If at birth the brain is a *tabula rasa*, as John Locke and other strict empiricists have it; if there is no strong innate component, then it remains a mystery how we can ever achieve knowledge. Evolution and genetics would not be the explanation.

On the other side, specifying this supposedly innate component is not easy. How do we find out the *cognitive inventory* of newborn babies? They cannot talk, so we have to rely on observations of behavior. But the behavioral spectrum of newborns is rather limited. Those things a newborn does not master from the outset, but only days, months, years after, may always be claimed to be acquired individually, hence to be due not to phylogeny, but to ontogeny. Many experiments that could be, in principle, informative are unacceptable for moral reasons. Nobody will intentionally prevent a baby from the experience of color or music in order to find out how a child will develop without these stimuli. Therefore, it is very difficult to find conclusive evidence for the genetic preconditions of cognitive achievements.

Ethologists find help by comparing species. Traits occurring in many species, especially if the latter are narrowly related, are supposed—in the sense of a legitimate working hypothesis—to be innate. Thus, without doubt, it is informative to investigate the cognitive achievements of man's kinship, the great apes. But these talk even less than human babies, and innate components are again difficult to spot.

Happily there is a fertile analogy to cognition: language. True enough, investigating language acquisition faces similar obstacles as investigating cognition. As with cognition, it does not suffice to look at the result, that is, at the different linguistic products or different languages. What is at stake is the *ability* to speak, that is, to learn a language, to use and to form it. How come that we speak? How come that humans can do something that no other animal can do? Is this due to a biological, a genetical, hence phylogenetical component? How does it look like and how did it arise?

If our language faculty has its origin in organic evolution (and for a naturalist there is no doubt about this), then there must have been intermediate steps in this development. Unfortunately such intermediate steps are neither recent nor evidenced by fossils. But the comparison of languages gives at least some cues to innate elements. Hints at an innate component of language ability in humans have been strengthened in recent years. They come from research on Creole languages and on deaf-mutes.

CREOLE LANGUAGES AS AN ARGUMENT FOR THE EXISTENCE OF INNATE STRUCTURES

It sometimes happens that members of a linguistic group live in an environment where other languages are spoken, be they merchants, refugees, slaves, or inhabitants of a colony. In such cases they develop, in order to communicate, typical hybrid languages, so-called *pidgin* languages. (The word "pidgin" comes from the Chinese pronunciation of the English "business", but the expression is used for all such mixed languages.) Pidgin languages are quite simple in their vocabulary and even more in their grammar. They do not count as full-blown languages.

Very often the *children* of immigrants develop their own language, called "Creole" languages. At the beginning, creoles were the descendants of white immigrants in all of South America (white creoles) or the descendants of black slaves in Brazil (black creoles). Nowadays, the term "creole" applies to all languages developed by immigrants of the second generation, be it on islands or coast areas of Middle America, Western Africa, the Indian Ocean or the Pacific area. Creole languages are complex languages rooted with a vocabulary in totally different "mother tongues," mostly of colonists. Thus, Jamaica-Creole rests on English, Guyana-Creole on Dutch, Haiti-Creole on French, Crioulo in Western Africa on Portuguese. In their *grammar*, however, these languages are quite autonomous, neither dependent on the original language of the immigrants nor on the language of the "host country" or of the colonizers.

The colonies being quite apart and having no exchange, or nearly none, creole languages must have developed independently of one another. Yet, in recent years linguists have discovered that these creole languages are surprisingly similar in their structure, that is, in morphology and grammar [14]. How is that to be explained?

Traits common to all humans are explained as being genetically conditioned. If there is an innate language faculty, as claimed for a long time by rationalists and nativists, and more recently by Noam Chomsky and Steven Pinker [15], then there should be features common to all natural languages. The search for such linguistic universals was not extremely successful; it uncovered only very abstract principles. Creole languages, however, share many and very concrete traits.

Not conclusive, but at least suggestive is, therefore, the conjecture that these shared traits are due to a biological-genetic component. This is precisely the claim of Derek Bickerton, a leader of this research. According to him, the innate language component can develop freely only if it is not suppressed by corrections from outside, and just this is the case with creoles. Their immigrant parents don't master the local language, and the children usually do not get scholar education. Therefore, the structural similarity of creole languages of independent origin is used as evidence for the existence and influence of a strong genetic component in language ability.

CHILDREN GRAMMAR AND THE LANGUAGE OF DEAF-MUTES

This conjecture is supported by more recent findings. Children do not master their mother tongue immediately, but start with characteristic *mistakes*; they use some kind of "infant" grammar, violating the respective "correct" grammar in many ways, e.g., with respect to double negation or to interrogative forms. According to Daniel Slobin, these infant grammars are strikingly alike. What is more, they have very much in common with Creole languages! This suggests that infant grammar is partly innate. In most cases this innate grammar is overcome by the native tongue coming from outside, except with Creoles.

These findings confirm Chomsky's thesis that there is an innate language acquisition device, but they contradict another of Chomsky's conjectures. According to Chomsky all natural languages should fit into the innate linguistic structure. According to Bickerton and Slobin, however, they do *not* fit this innate structure in every respect; that's why children make typical mistakes, and that's why this infant grammar could be detected [16].

New investigations with deaf children point into the same direction. In order to communicate with each other they develop an extensive system of signs and gestures. American psychologists have analyzed and compared such sign languages of deaf children from America and Taiwan. They found that although these children had never met before, they gesticulated in stunningly similar ways and in manners they could not have learned from their parents [17]. This is a kind of involuntary Kaspar-Hauser experiment: Since the deaf children grow up without linguistic stimulation from outside, they have to develop such structures out of themselves. Here again, a biological-genetic explanation suggests itself.

Suppose such explanations are correct: what does that mean for our cognitive abilities? Language and cognition, albeit not identical, are narrowly intertwined. Without language there is no higher cognition, and without cognition language does not make much sense. For Chomsky, language is therefore a kind of sonde giving us insight in the organization of mental processes. Thus, the evolution of a language faculty must have gone along with an evolution of cognitive faculties. If one part is plausible, so is the other. No wonder then that Chomsky's disciple Steven Pinker not only wrote a book on language, but also one on thinking [18].

In arguing from success we use success as evidence for the quality of a premise. Science is successful as far as it achieves its goals. And a scientific theory is called successful if it promotes our goals. Such successes corroborate the premises made by the respective theory. One fundamental premise of natural science, possibly of all empirical science, is *realism*. How can we argue for realism?

Often enough, it is the success of science which counts as the best argument in favor of realism. As an example we cite the early Hilary Putnam: "The typical realist argument against Idealism is that it makes the success of science a miracle" [19]. In fact the realist can explain the success of science, whereas the antirealist cannot. For if quarks and quasars really exist, then it is no wonder that theories claiming or presupposing their existence are successful. If, however, these objects do not exist at all, how is it then that with these theories we make correct predictions and solve so many more problems?

But even the success of science is of course no proof for realism. And, vice versa, the fact that idealism, positivism, instrumentalism, constructivism cannot explain something, does not refute them. Still we may say that realism explains more. In theories of empirical science, explanatory power is an important trait to judge theories. (Other traits are noncircularity, internal and external consistency, testability, and test success.)

True, neither realism nor its counterparts are theories of empirical science. They rather help us to do science and to interpret our results. But if we want to judge metatheories, metaphysical positions, methodological attitudes, heuristic rules as well, then we need criteria on this level, and then explanatory power plays again an important role. And by this criterion realism fares much better. Some philosophers think that realism is historically testable, but disagree on the question whether it has stood up to this test.

There is an important objection. Couldn't it be that there are several ways to do justice to the same experiences? Could there not be empirically equivalent theories contradicting each other in their basic premises? Following radical constructivism or conventionalism, could we not work with arbitrary theories?

It is not easy to name concrete examples for empirically equivalent theories contradicting each other. Even so, such theories are thinkable. As a matter of principle, to account for finitely many experiences, even infinitely many empirically adequate theories may be constructed. From the success of a theory, we cannot derive its truth. Nor may we infer the truth of realism from its success. Is there a better argument for realism?

THE FAILURE OF THEORIES AS A BETTER ARGUMENT FOR REALISM

Failure is the opposite of success. A theory fails if something runs counter to what the theory makes us expect. This applies on the theoretical level, for instance with predictions, as well as on the practical level, let's say with bridges or tools. What we mean when ascribing success or failure to a theory does evidently not depend on our answer to the question of realism. This independence not only applies to the meaning of the concepts "success" and "failure," but also to the assessment whether a prediction is confirmed or not, or whether a tool works or not. There is no danger then that the realist sees successes where the antirealist cannot see any. Nor will the realist want to explain something where the antirealist does not see any problem, no need for an explanation.

Historically, there are more wrecked theories than successful ones. We are not aware of this because we care so little for such theories. And we don't care because, in normal education, there is no time to teach, to analyze and to criticize refuted theories. But what makes so many theories fail? The antirealist has no answer to this question. He may describe the failure in other words. He may say that the set of acknowledged observational statements has turned out inconsistent, or that his tool did not meet his expectations. But these rewordings do not explain anything. They just say in what sense the theory has failed; they elucidate the failure accepted before. But they don't answer the actual question, they don't explain the failure.

For the realist, the answer is easy enough. A theory fails because it is wrong, *i.e.,* because the world is not as the theory submits. But in order to be different the world has not only got to exist; it must also have a specific structure which we may hit or miss. Thus realism not only explains the success, but also the failure of theories. Even so, there is an asymmetry: For success there are more explanations, even nonrealistic ones. But not for failure. The failure of theories is therefore a much better argument for realism, presumably the best one.

EXTINCTION AS AN ARGUMENT FOR THE EFFECTIVENESS OF NATURAL SELECTION

Natural selection is differential reproduction due to varying fitness. According to evolutionary epistemology, cognitive abilities raise fitness; therefore, selection works for better cognition, at least in cases where such improvements are useful, available, and not too costly. As far as our cognitive ability is (taken to be) reliable—that is, in the mesocosm—we may *explain* this reliability by the effect of selection.

The fact that humans survived evolution under competition makes plausible the reverse conjecture, namely, that our cognition cannot be too bad. This inverted argument is not altogether compelling; above all, it is not sufficient to exhibit our cognitive faculty as unfailing or to specify some bit of knowledge as certain. By this argumentative step we may *justify* our (limited) trust in our cognitive apparatus.

Obviously evolutionary epistemology makes constitutive use of the theory of evolution, first of all of the principle of natural selection. Without natural selection, both argumentative possibilities mentioned above would escape us. For evolutionary epistemology it is, therefore, not irrelevant whether this important factor of evolution is effective or not.

What testifies the effectiveness of natural selection? Usually the multiplicity of species counts as the best argument. Wasn't the different finches on the Galapagos islands which aroused in Darwin the idea of natural selection? And if we are told that there exist on earth at least five million, possibly twenty million different kinds of organisms [20] (without counting bacteria or viruses), all occupying their own ecological niches, then we are even more easily convinced of the effectiveness of natural selection.

But again there is an objection: Could there not be several, even many, ways to put up with the same environmental conditions? Could not totally different species occupy the same ecological niche? Is it, then, a question not of natural selection, but of mere chance and history that species are formed and populate the earth?

There are in fact arguments supporting this interpretation. We have concrete cases where similar ecological niches are occupied by completely different species: The niche of the great pasture animals is occupied in the savannas of Africa by hoofed animals, in Australia by kangaroos. According to the neutral theory of evolution, developed since 1968 by Motoo Kimura, many genetic (molecular) changes are chance processes. From this slow and uniform "molecular clock," we can determine the age of a species, that is, the time elapsed since it branched off its closest relatives. Is organic evolution a mere chance process with natural selection playing a minor role or none at all?

Again, there is a better argument for the effectiveness of natural selection: the extinction of species. Evolutionary biologists take the number of extinct species to be at least one hundred times that of the existing ones. Ernst Mayr even guesses that 99.9 per cent of all evolutionary lines are extinct. Why did so many species die out?

Occasionally species get extinct more or less accidentally, by a flood or by the impact of a meteorite. As with individuals, we might call this "situational" death. It would be absurd, however, to include all extinctions under situational death. In contradistinction to individual aging and dying, there is, as far as we know, no pre-programmed species extinction. Thus, we must look for external causes in most cases. What makes organisms, populations, species fail?

For selectionists the answer is simple. Populations and higher taxonomic units die *either* because they cannot put up (any more) with environmental conditions, most of all when these change fast, *or* because they are displaced by fitter organisms, possibly by superior members of the same species. Both cases instantiate mechanisms of natural selection.

How do antiselectionists, *e.g.*, neutralists, explain species extinction? Not at all. The reason is not that they couldn't cope with the term "extinction." Antiselectionists cannot offer a plausible explanation of extinction. The theory of natural selection has higher explanatory power than any antiselectionist theory, say the neutral theory.

Now we may reiterate what was stated above: selection theory not only explains the success, but also the failure of species. Again, there is a pronounced asymmetry: There are other explanations for success, but not for failure. The failure of species is therefore a much better argument for the theory of selection, presumably the best one.

THE ARGUMENTS SUPPORT EACH OTHER

It should now be apparent why we switched so abruptly from the epistemological problem of realism to a problem of evolutionary biology. By that move we uncovered a far-reaching analogy which we could follow right into its verbal formulation. It is tempting to use this analogy as a further argument. Then both conceptions, the realist one and the selectionist one, can support each other. The two arguments do not, however, depend on each other.

A further nice analogy with mutual support is furnished by the phenomena of convergence. In the development of science, we find a phenomenon we could call "convergence of research." There are several kinds of convergence: convergence of measurements, convergence of measuring methods, convergence of theories. How do they come about? The antirealist has no answer, whereas the realist has a ready reply: Research converges because there are real structures which we may uncover and do indeed uncover slowly. This is what the realist rates as scientific progress. Here again the superior explanatory power of realism is remarkable.

Convergence is also observed in evolutionary biology. There are similar traits that originated independently, *e.g.*, the streamline design of ichthyosaur, shark, tuna, and dolphin. These are external conditions, especially the need to advance fast in water, which have promoted this trait. The effectiveness of natural selection is especially conspicuous here. The analogy between the two lines of thought is outstanding. That the word "convergence" is used in both cases is not essential, but makes the analogy all the more suggestive.

It is tempting to apply the concept of convergence not only to body traits, but to cognitive achievements too. We might say that our different sense organs supply us with a "convergent" view of the world, *e.g.*, when an apple is seen, felt, and tasted. The signals from the sense organs are rather different, but are combined to build an undivided object in perception. Similar considerations apply to higher cognitive achievements. This kind of convergence may be interpreted in favour of realism. Only if there are unified outside objects does it pay to reconstruct such objects in our imagination.

Thus, it is obvious how much evolutionary epistemology is connected with other conceptions without being displaced by them: with realism, with naturalism, with evolutionary theory, with the development of science, with an evolutionary philosophy of science. This concatenation cannot be further explored here.

NOTES

1 Koestler (1959), Part Three; H. Kragh (2000).
2 v. Weizsäcker *et al*. (1977).
3 I owe this note to M.T. Ghiselin (1973, p. 965).
4 Simpson (1963, p. 84).
5 Cf. the recent book by Roger Penrose (1997).
6 Wittgenste, proposition 4.11.22 (1921, English 1922).
7 Vollmer (1987).
8 Vollmer (1994).
9 Quine (1969).
10 Quine (1969, p. 126).
11 This is even a book title: Ruse, M. (1995), *Evolutionary Naturalism*. I should mention that Roy Wood Sellars has already sketched such a naturalism in his (1922) *Evolutionary Naturalism*.
12 For a more extensive discussion of objections to evolutionary epistemology see Vollmer (1985, pp. 217-327).
13 For the concepts of multiple functions and of change of function see Vollmer (1986).
14 Bickerton (1983, 1984).
15 Chomsky (1966), S. Pinker (1994).
16 This is a nice example for the *cognitive value of failures*, *i.e.*, for the fact that we may learn especially much about a system if it does *not* work.
17 For the gestures of deaf-mutes, see Goldwin-Meadow and Mylander (1998).
18 Pinker (1997).
19 Putnam (1976, p. 177).
20 Kaplan (1985).

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