Evolution as a Cognition Process: Towards an Evolutionary Epistemology

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ABSTRACT: Recently, biologists and philosophers have been much attracted by an evolutionary view of knowledge, so-called evolutionary epistemology. Developing this insight, the present paper argues that our cognitive abilities are the outcome of organic evolution, and that, conversely, evolution itself may be described as a cognition process. Furthermore, it is argued that the key to an adequate evolutionary epistemology lies in a system-theoretical approach to evolution which grows from, but goes beyond, Darwin's theory of natural selection.

KEY WORDS: Evolutionary epistemology, Darwinism, systems theory.

> He who understands a baboon would do more toward metaphysics than Locke.
>
> Charles Darwin

INTRODUCTION

Charles Darwin did not doubt that humans, like other living beings, result from evolutionary processes. He was, indeed, prepared to speculate on the looks of human ancestors. In 1872, he remarked: "The early progenitors of man were . . . covered with hair, both sexes having beards; their ears were pointed and capable of movement; and their bodies were provided with a tail, having the proper muscles. Their limbs and bodies were also acted on by many muscles which now only occasionally reappear, but are normally present in the Quadrumana" (quoted from Barrett, 1977, vol, 2, p. 168).

Most of Darwin's contemporaries were shocked at these conclusions — and, even today, many people do not want to recognize that man is something like a modified monkey. But, even more profound than Darwin's claims about our physical bodies, were his implications for our minds. Indeed, the very weightiest consequence of Darwin's theory, and of the theory of evolution in its general sense, was the claim that human mental capabilities are the outcome of organic evolution. In his *The Descent of Man* (1871) and *The Expression of the Emotions in Man and*

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Animals (1872) Darwin worked out, with great insight, basic principles governing the emergence of phenomena such as conciousness, thought, language, and morality. Thus, he was the founder of what we might call *evolutionary psychology* (cf. Ghiselin, 1969; Wuketits, 1984a). (It is true that Herbert Spencer's pre-Darwinian approach to psychology was no less based on evolution, but Darwin's naturalistic view, unlike Spencer's, was founded on empirical evidence, and not mere speculation.)

Today, this evolutionary psychology — hypothesizing that psychic and mental activities in humans, having their roots in the animal kingdom, are the products of organic evolution by natural selection and that even the most complex human thought processes have evolved alongside biological structures and functions — points the way to a new approach to philosophy: so-called, *evolutionary epistemology*. Grand claims have been made on behalf of this latter. Indeed, the evolutionary approach to *human* knowledge has even been called a "New Copernican Revolution" (see on this Wuketits, 1984b). Be this as it may, a re-evaluation of cognition and of the status of our knowledge-claims is obviously under way.

But, what does not yet seem clear is whether or not natural selection, in the somewhat limited way used by biologists, offers a sufficient explanation of cognitive processes. I believe that it does not. The aim of this paper, therefore, is twofold: First, I shall outline the basic assumptions and main tenets of evolutionary epistemology, staying at a general level acceptable to most of its advocates. Second, I shall point out the relevance of a *systems-theoretical* view of evolution, which extends Darwin's theory of natural selection, and which I believe is the key to an adequate, comprehensive, evolutionary theory of knowledge. I accept that Darwin was on the right track in arguing that selection is, say, the "driving force" of evolution, but I feel in regard to some features of evolution his arguments were incomplete. Now is the time to establish an evolutionary theory considering all aspects of organic evolution — a theory paying due account to the complexity of living systems, humans included.

EVOLUTIONARY EPISTEMOLOGY: A GENERAL ACCOUNT

As far as I know, the term "evolutionary epistemology" was coined by Donald T. Campbell, in order to characterize the natural-selection approach to epistemology — an approach which is, for him, a type of *descriptive epistemology* (Campbell, 1974a), or, using Quine's concept, "epistemology naturalized" (Quine, 1969). In his seminal essay (first published 1974, reprinted 1982), Campbell writes:

> An evolutionary epistemology would be at minimum an epistemology taking cognizance of and compatible with man's status as a product of biological and social evolution. In the present essay it is also argued that evolution — even in its biological aspects — is a

knowledge process, and that the natural-selection paradigm for such knowledge increments can be generalized to other epistemic activities, such as learning, thought, and science (Campbell, 1974b, p. 413).

Unpacking this passage, let us start with its central claim, namely that *evolution is a knowledge/cognition process.*[1] (For like claims, see for instance, Kaspar, 1984; Lorenz, 1973; Plotkin, 1982; Riedl, 1980; Tennant, 1983a; Wuketits, 1984a, b). The claim is based on the idea that any living system is a "knowledge-gaining system". That means that organisms accumulate information about certain properties of their environment. Hence, life generally may be described as an information process, or, to put it more precisely, an information-increasing process. All organisms are equipped with particular organs (e.g. sense organs) and with a nervous system — or, as it is the case at the level of unicellular living systems, special organelles — which in their totality constitute the organism's "perceiving apparatus". This apparatus functions in a way analogous to a calculation machine. It accumulates information about the organism's specific environment, thus, in a sense, modelling certain structures of reality. Ultimately, this information gained about the environment is stored (via, reproduction and selection) in the genome. This process of information-storage functions in a way akin to memory.

Modelling reality or, at least, certain parts of it, is vital for any organism. Information-processing, therefore, serves as a mechanism for the sake of survival: the better the model of reality, the better the chance of survival. Thus, cognition (knowledge) is useful in a strict biological (evolutionary) sense. To put it in Darwinian terms: cognition increases the fitness of an organism. If, now, there is a linking between sense organs and environmental conditions, then this linking, by increasing the organism's fitness, is of evolutionary advantage. A paradigmatic example of such an advantageous link is an animal's eye (see Table I, after Vollmer, 1984). Let me remind the reader of Plato's metaphor, as it was paraphrased by Goethe: "Were the eye not attuned to the Sun, / The Sun could never be seen by it." In evolutionary epistemological terms, the eye is indeed attuned to the sun, for it has evolved and been selected in order to perceive light.

Of course, in considering the partial representation of reality by any particular organism's perceiving apparatus, we have to take into account the fact that the range of perception varies from one species to another. Different species perceive different parts of reality, and consequently the "world pictures" of animals differ from each other.[2] For instance, the world pictures of primitive organisms, for example worms, are completely different from those of higher organized animals, say, birds or mammals, which latter have complex central nervous systems (CNS) and brain structures. Despite these differences, however, all organisms have the ability to perceive — to model — certain cuts of the external world. Hence,

TABLE I

Eye: Facts and fits	Advantages (survival value)
The sensitivity of the retina coincides both with the "optical window" of the earth's atmosphere and with the area where the radiation of the sun has its maximum of intensity.	Normal objects reflect sunlight and thus can be seen, caught or avoided.
Different wavelengths are interpreted as different colours	Objects are recognized and distinguished more easily and reliably.
A superposition of all wavelengths is not interpreted as a colourful medley, but rather as colourless (white) light	Normal daylight does not carry information; only deviations from the normal distribution are informative and worthy of perception
The lower limit of sensitivity for a photoreceptor in the retina is one photon. But only simultaneous excitation of several adjacent cells yields a sensation of light in consciousness. The wiring of the optical nerves thus censors the incoming stimuli.	Spontaneous activity of the retinal cells, occasional misfiring and statistical fluctuations of the flow of photons ("noise") are devoid of information and are eliminated by the censorship.

they can generate world pictures controlled by genetically stabilized programmes incorporating "how-to-behave-in-order-to-survive" imperatives. The programmes themselves result from evolution by natural selection.

INBORN MECHANISMS

The discussion has brought us naturally to the idea of "inborn mechanisms". If evolution is a question of learning and of knowledge, then each individual living system is not, and cannot be, a *tabula rasa*. Rather, such a system has to be equipped with innate dispositions, which might be described as "*a priori* teaching mechanisms". Such a conclusion, based on biology, resonates with conclusions towards which philosophers have been driven. Karl Popper, in particular, has argued that "the *tabula rasa* theory is absurd", and that "at every stage of the evolution of life and of the development of an organism, we have to assume the existence of some knowledge in the form of dispositions and expectations" (Popper, 1972, p. 71). And complementing this, there is empirical evidence. For instance, ethologists have offered strong evidence that the behaviour of animals depends crucially on innate teaching mechanisms. For instance, the father of modern ethology, Konrad Lorenz, states categorically:

> All the teaching mechanisms ... contain phylogenetically acquired information that tells the organism which of the consequences of its behaviour must be repeatedly

> attained and which ought to be avoided in the interest of survival. This information is preponderantly localized in the perceptual organizations which respond selectively to certain external and/or internal configurations of stimuli and report them, with a plus or minus sign added, to the central mechanisms of learning (Lorenz, 1965, p. 16).

It is important to note that the innate teaching mechanisms in animal behaviour, though modifiable by learning, cannot be wiped out; they are integral elements of an organismic system, and genetically fixed in the course of evolution by natural selection. In short, "they are the products of selective mechanisms, which, among all 'initial products', favour and stabilize the one which best copes with the conditions of living and surviving" (Wuketits, 1984a, p. 6).

Grant now that living systems "calculate" their environment, and that their chances of surviving under specific environmental conditions depend on a behavioural capacity which is controlled by innate dispositions — collectively constituting a so-called *ratiomorphic apparatus*.[3] At once, one wants to know about the precise nature of these innate dispositions. Naturally, different writers have different proposals; but, the most comprehensive (and representative) comes from the pen of Rupert Riedl (1980, 1984). He proposes a "system of hypotheses", which underlie any single organism's behaviour. They represent, so to speak, behavioural constraints. (The term "hypothesis", of course, is not to be understood here as a consciously formed, scientific theory, but rather as a pre-conscious expectation.)

Let me summarize. (Full details in Riedl, 1980).

First hypothesis: The probability of any particular thing/happening increases with the number of confirmed expectations. (This hypothesis suggests that the thinking of any organim is based on the expectation that what has frequently been confirmed will probably be true.)

Second hypothesis: In looking at similar events or objects, you can disregard the differences. (This process of elimination relies upon what is known under the concept "*Gestalt* perception" or "*Gestalt* abstraction": The organism expects — for it is so "told" by its ratiomorphic apparatus — that the most-frequently recognized coincidences will recur, whatever the differences.)

Third hypothesis: Increasing constancy of conjunction between events, increases the probability that the events are causally related, and that the former event is the cause of the latter.

Fourth hypothesis: The probability that two or more objects, having some features in common, will serve the same purpose, increases with the number of the common features.

According to Riedl, these principles, embedded within organisms' ratiomorphic apparatuses, do not operate independently. Rather, they constitute a nested hierarchy of behavioural constraints. However, phylogenetically, the fourth hypothesis is the youngest one. Lower organized animals, worms, snails, and the like, do not — and actually are not able to — *reflect* the purposes of the objects which surround them. And, even most of the vertebrates — exceptions being primates and other highly organized mammals, (dolphins, dogs, and some others) — have little capacity for reasoning about purposes, because they are not capable of "insight learning". Indeed, the fourth hypothesis, which Riedl labels the "principle of last causes" necessarily presupposes conscious behaviour, even though, it is "perhaps not older than the first stages of consciousness, of spatial representation in the CNS" (Riedl, 1984, p. 44). Hence, the hypothesis has to be comparatively recent.

But, whatever the particular ordering of the evolutionary epistemological hypothesis may be, the key claim remains that the principles (hypotheses) of the ratiomorphic apparatus have been developed phylogenetically, by the means of natural selection, favouring those patterns of behaviour which enhance the organism's chances to survive. If you look at the behaviour of ants, crabs, fishes, birds, or whatever you want, you will soon recognise that all animals, despite their differences in organization and complexity, calculate (or "calculate") their environment, by expecting that experiences made in the past will be confirmed now and tomorrow. Usually, this is not a conscious expectation, but the ratiomorphic apparatus is functioning in ways at least analogously to consciousness — it functions *as if it were* a conscious apparatus. Thus, it operates as a "logic of life".

GETTING TO KNOW REALITY

Given the picture just sketched, we might truly say that life is a "belief-gaining process" (Tennant, 1983a, b): The better an animal has experienced reality, the stronger its expectation ("belief") that things will appear just as they already have been experienced.

But, what is this reality that is being experienced? Or rather, at what level can we claim to assert its existence? Generally, evolutionary epistemologists have conceeded a tentative element in their claims about reality. They are, therefore, *hypothetical realists*. Vollmer (1984, p. 83), for one, states the evolutionary epistemology presupposes hypothetical realism, stressing "the hypothetical character of all knowledge", taking "even the existence of the world as a conjecture."

However, it is important to recognize that in this context, "hypothetical" is being used in a rather technical sense. From an everyday perspective, there is nothing particularly hypothetical about reality. We have good reason to believe that the world which surrounds us *really* exists. Life itself actually shows that it is incombent upon us to accept an external world — a world having certain structures which, at least partially, are knowable.

Moreover, thinking back for a moment to points made about the eye, one might reasonably suggest that there is some congruence between an organism and its environment. In other words, there is congruence between subjective (cognitive) impressions and objective (real) structures. Evolutionary epistemology does not assert that any organism's world picture is perfect, or that human knowledge (in particular) is complete (having grasped the Kantian thing-in-itself). Rather, it asserts that *some parts* of the world are realistically perceived, and that the touchstone of the organism's perception is some kind of reality.

Analogously, if one accepts that evolution is a knowledge-gaining process and that survival depends on calculating certain structures of reality, then the evolutionary epistemologist is also ready to recognize that animals are hypothetical realists, inasmuch as they "hypothesize" that their perception of objects has offered a "true image" of these objects. With special regard to human knowledge Konrad Lorenz, in his classic essay '*Kants Lehre vom Apriorischen im Lichte gegenwärtiger Biologie*' (1941), made the point:

> Everything is a working hypothesis. This holds true not only for the natural laws which we gain through individual abstraction a posteriori from the facts of our experience, but also for the laws of pure reason. The faculty of understanding does not in itself constitute an explanation of phenomena, but the fact that it projects phenomena for us in a *practically usable* form on to the projection-screen of our experiencing is due to its formulation of working hypotheses, developed in evolution and *tested through* millions of years (Lorenz, 1941 [1982, p. 132]; my italics).

To be sure, except for man, no organism *consciously* reflects on its own existence and on the world surrounding it. But it is, nevertheless, crucial that *every* organism's innate teaching mechanisms — the ratiomorphic working hypotheses — operate reliably. This means that it is important to any organism that it gain a realistic perception of certain objects.

And, as evolutionary epistemologists, this takes us back again to natural selection and, thus, to a process resembling the "trial-and-error method". Consider, for example, a leopard hunting for antelopes. A thousand and one leopards have, again and again, experienced catching an antelope. Necessarily, therefore, any member of this species has truly a realistic perception of its prey. Otherwise, the species would not have survived. This much is trivial. But, what evolutionary biology and evolutionary epistemology tell us is that the individual leopard's realistic perception of antelopes (and, of course, of other objects) has been genetically stabilized by natural selection. It is, therefore, actually *a posteriori* knowledge about certain phenomena of the world, laid down in the peculiar nucleotide sequence of the DNA in the leopard's genes. This, and nothing else, is meant when evolutionary epistemologists argue that animals (including man) are "hypothetical realists". If they were not (hypothetical) realists, they hardly would survive. Remember George Simpson's famous illustration: "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" (Simpson, 1963, p. 98).

Conversely, it must be appreciated that although a perception of reality may be a necessary condition for survival, it is hardly a necessary one. It is well-known that millions of species have died not. Indeed, no species persists foreover. On an average, the life-span of marine invertebrate species is limited to 1,000,000 years, terrestrial mammal species persist a mere 50,000 years (cf. Dobzhansky *et al.*, 1977). There are exceptions: but, sooner or later, every species dies out. Natural selection cannot guarantee indefinite survival. Realism is not enough!

Moreover, while thinking of limitations, we must not forget that the innate teaching mechanisms of which we are speaking, stop working reliably *outside* the area within which they have been selected. The world pictures of animals differ from each other. Because different animals live in, and are adapted to, different environments, to different "ecological niches", so the world which is to be calculated by the perceiving (ratiomorphic) apparatus of any particular organism is but *one* section of reality. Animals with different evolutionary histories, with different sensory powers, with different needs, see different aspects of reality. Different realities, even.

HUMAN KNOWLEDGE

This brings us conveniently to our own species, for what has just been said obviously applies to us, as well as to other animals. Humans, like any other organism, have their specific "cognition niche", that is to say they are adapted to particular structures of reality, which — according to Vollmer's term — may be called "Mesocosmic structures": "Our mesocosm is that section of the real world we cope with in perceiving and acting . . . Mesocosm is, crudely speaking, a *world of medium dimensions*" (Vollmer, 1984, p. 87). What is completely new in humans, however, is their ability to transcend their mesocosm. By the means of their *rational apparatus*, humans, unlike any other organism, are able to investigate the sphere "behind the scenes" of their existence as a biological species: They are "cultural animals", too.

As I have already pointed out, the most significant anthropological (and philosophical) consequence of evolutionary theory — a consequence which is central to evolutionary epistemology — is the assertion that human mental structures, meaning human rationality, morality, scientific thought, and even religious belief, are the result of evolution. One might therefore suspect that evolutionary epistemology neglects the importance of culture, falling into a kind of ontological reductionism. However, this is not the case.

Evolutionary epistemologists do not assert that culture (or *cultural evolution*) is fully explicable in terms of the theories and methods of biological evolution. They assert merely that there are biological determinants of culture (Wuketits, 1984c). As Vollmer (1984, p. 85) puts it: "Cultural evolution builds on biological facts and faculties; it cannot dispense with biological preconditions. Biological determinants are part and parcel of culture and cultural evolution." This should not come as a surprise to anyone who has recognized that (human) mental structures, the "producers" of cultural activity, depend on brain functions, which are a result of organic evolution at all, which rely upon complex interactions at the level of neurons. After, from a biological perspective, the story of human evolution is virtually synonymous with the story of the growth of the brain (Dobzhansky *et al.*, 1977).

But, if human evolution is the story of the brain, what then of the mind? Simply stating, without arguing, the most favourable option for the evolutionary epistemologists (and certainly the one favoured by me) is one pointing to some form of *emergentism*. Mental states in humans appear to be the emergent results of specific interactions among material elements (i.e. the structural components of the brain). This position is non-reductive, and yet non-vitalistic (in the sense of supposing the mind to be some mysterious new entity or substance or such thing). As evolution in general may be said to be a process of *integration*, linking together material elements into ever-newer systems of greater complexity, thus the evolution of the brain in particular has been a process by which neurons are linked together into yet-more complex patterns of organization and newer stages of functional order. We do not yet have complete knowledge about the specific arrangement of nerve cells in our brain, but we may assume that this arrangement has been the precondition and cause of our peculiar cognitive abilities like *self-awareness*.

It is almost a truism to say that this awareness is an evolutionary novelty, unknown in systems of the subhuman world. But, as Lorenz (1973 [1977, p. 39]) says: "there is nothing supernatural about a linear causal chain joining up to form a cycle, thus producing a system whose functional properties differ fundamentally from those of all preceding systems". Hence, without falling into reductionism, we can try to understand our own mental abilities, including rational and moral behaviour, as the *natural* outcomes of evolution (Wuketits, 1986).

Evolutionary epistemology, then, neither claims that cultural evolution is reducible to biological processes, nor does it assert that cultural evolution is a mere extension of organic evolution. Cultural evolution indeed presupposes biological evolution — particularly the hominid's transformations due to increasing brain capacity, bipedal locomotion, and so forth — however, it has transgressed organic evolution and shows a certain autonomy.[4]

Nevertheless, at this moment let us stress the dependence of our culture on our biology, reverting back to the fact that although our knowledge of reality (if you like, our reality) will differ from the animals (if nothing else, thanks to self-awareness, we alone can know that we know), like the animals our awareness of the real is shaped and constrained by innate principles (of a kind, and perhaps at one with those of Riedl listed above). Concluding this (part of the) discussion, therefore, let me simply draw your attention to striking parallels between evolutionary epistemology and Kant's apriorism. In both cases, we have the mind interpreting the world, and thus shaping reality. And indeed, I, Lorenz (1941, 1973), Mohr (1977), Riedl (1980, 1984), and other advocates of evolutionary epistemology have argued that the *a priori* in the sense of Kant must be explained in evolutionary terms. Supposing that evolution is a congition process, these evolutionary epistemologists have concluded that the prerequisites of human thinking in fact are *a priori* for each individual, but that they are phylogenetic *a posteriori.*

However, I myself would warn against drawing too strong a parallel between evolutionary epistemology and Kantian epistemology. The evolutionary approach to human knowledge transgresses the boundaries of Kant's (and Kantian) philosophy: Kant's epistemology is aprioristic in that sense that it *prescribes* how the acquisition of knowledge may (and should) proceed towards (objective) truth. Evolutionary epistemology, on the contrary, *describes* the acquisition of knowledge. It focusses on human cognitive abilities, and tries to explain these abilities according to the theory of evolution. Therefore, evolutionary epistemology ends at that point where Kant's epistemology starts (Oeser, 1984). The one tells us how things are. The other tells us how things must be, if they are to be done properly. The one gives us a contingent, historically shaped reality (the reality of our biological species). The other (supposedly) directs us towards the true reality.

THE IMPORTANCE OF SYSTEMS THEORY

Thus far, I have sketched an evolutionary approach to epistemology acceptable to many. In concluding this discussion, I want now to suggest a revision/addition which goes beyond the consensus. Evolutionary epistemology depends on evolutionary theory, and it is here that I make my move. Consider, for a moment, the importance of the notion of *adaptation.* Listen to Maynard Smith, who — among many others — highlights adaptation as the central problem of life:

> Life is an active equilibrium between the living organism and its surroundings, an equilibrium which can be maintained only if the environment suits the particular animal

> or plant, which is then to be 'adapted' to the environment. If an animal is placed in an environment which differs too greatly from that to which it is adapted, the equilibrium breaks down; a fish out of water will die (Maynard Smith, 1975, p. 15).

Expectedly, therefore, the concept of adaptation plays an important role in evolutionary descriptions and explanations of cognitive structures. It is crucial to evolutionary epistemology. Indeed, more than forty years ago, Lorenz centered in on adaptation in the following way:

> [The] central nervous apparatus does not prescribe the laws of nature any more than the hoof of the horse prescribes the form of the ground. Just as the hoof of the horse, this central nervous apparatus stumbles over unforeseen changes in its task. But just as the hoof of the horse is *adapted* to the ground of the steppe which it copes with, so our central nervous apparatus for organizing the image of the world is *adapted* to the real world with which man has to cope. Just like any organ, this apparatus has attained its expedient species-preserving form through this coping of real with the real during its genealogical evolution, lasting many eons (Lorenz, 1941 [1982, p. 124]; my italics).

Adaptation is the key to an understanding of the fit between cognitive (subjective) structures and the structures of the external world. Remember, once more, the eye's way of functioning and Plato's metaphor.

However, there is something wrong with "adaptationism" in its strict sense, meaning the Darwinian sense where adaptation is simply the result of natural selection working on blind random mutations. A fish out of water indeed would die, but we know that some four hundred millions of years ago fish-like animals developed into terrestrial forms. Were these transformations just a result of selection working on blind mutation? One wonders, indeed, if orthodox Darwinians really believe this. Certainly, paleontologists have long hypothesized that "preadaptations" play a certain role in evolution. Thus, for example, Dobzhansky *et al.* (1977, p. 432) admit that preadaptations commonly give opportunity for "the successful invasion of a new habitat, especially when the creation of novel modes of life are involved." I feel, however, that more is needed. In order to explain preadaptations in particular, a special type of selection has to be supposed, namely *internal selection.* Let me explain.

Natural selection in Darwin's sense (and in the sense of the neo-Darwinian, and modern, Synthetic theory) is characterized as an external mechanism of evolution, operating through the environment. This outer mechanism — according to the Darwinian view — should suffice to explain even the most complex phenomena of evolution, say, for example, the emergence of the vertebrates' CNS. But, it clearly seems that this mechanism *does not* suffice. To be sure, natural selection as an external selective force *has* been a major component in evolution; but, it already presupposes other mechanisms at work. We should take seriously the remarks of, among others, Bertalanffy (1973, p. 160): "selection, competition and 'survival of the fittest' ... *pre-suppose* the existence of selfmaintaining systems; they therefore cannot be the *result* of selection."[5] In short, we must face up to the fact that Darwinism, in its strict version, tells us only half of the story.

As it happens, this limitation in Darwinism is a gap to which many evolutionists are already addressing themselves. For instance, Richard Lewontin notes that: "organism and environment are co-determined" (1982, p. 169). We evolutionary epistemologists must pick up on the internal factors, in evolution, recognizing that we have neglected "to understand how much of what is 'out there' is the product of what is 'in here'" (Lewontin, 1982, p. 169). We must be aware of the fact that organism and environment never can be separated form each other so that, as Lewontin (1982, p. 160) points out, "It is impossible to describe an environment except by reference to organisms that interact with it and define it." We have, then, to recognize that organism and environment are *mutually* related, and to suppose that there is a flow of cause and effect in both directions.

Thus, taking note of the interactions between organisms and their environment and the internal ("intraorganismic") constraints in evolution, we are propelled towards a *systems-theoretical* approach (Riedl, 1975, 1977; Wagner, 1983; Wuketits, 1982). Such an approach is based on Darwinism, but, goes beyond Darwin's notion of natural selection, overcoming his rather one-sided view of adaptationism. We must recognize that the unaided environment is not responsible for evolutionary changes. This is not to commit us to cryptic vital forces, but rather to appreciate that we have to consider both *external and internal mechanisms.* "The systems conditions which link different levels of complexity to feed-back loops of cause and effect are responsible for the evolution of life" (Riedl, 1977, p. 358). What I am saying, therefore, is that there are no outer (environmental) or inner mechanisms working independently. Rather, both internal and external mechanisms are linked together, in a system-theoretic manner.

Of earlier well-known evolutionary epistemologists, neither Karl Popper nor Konrad Lorenz took the step I advocate towards such an extended type of Darwinism. However, to his credit, Popper was near to recognizing the feedback loops of external and internal constraints in evolution. In his *Objective Knowledge*, for instance, he writes: "Organic systems may be looked at as the objective products or results of tentative behaviour which was 'free' — that is, not determined — within a certain realm or range circumscribed or bound by its internal situation (especially its genetic make-up) and its external situation (the environment)" (Popper, 1972, p. 149—50). What Popper did not recognize — and what, unfortunately, is missed in most natural-selection approaches to epistemology — is the necessity of a *systems-theoretical* conception, grasping the close interactions between internal and external constraints.

It is true that the advance of such a systems approach is hampered by unsolved problems about the genetical organization in higher organisms. Perhaps, however, one point where the systems theory approach to evolution would profit is in the study of *epigenetic rules*, — those regularities that channel the organism's development in a particular direction (see Lumsden and Wilson, 1981; Ruse, 1986a, 1986b). Such study might be supplemented by a search for an understanding of *genetic-learning mechanisms*. Riedl has already shown that the epigenetic system (that is, the totality of regulatory principles in the genome) must be capable of learning its specific organization (cf. Riedl, 1975, 1977). This would be a kind of "pre-selection" by the organism's internal constraints.

Elaborating, Riedl suggests "that the development of the epigenetic system will turn out to be guided and controlled by the patterns of functional dependencies of their own products" (Riedl, 1977, p. 361). Moreover, one might suppose,

> that the epigenetic system will permanently be forced to copy, and to imitate, the normative, interdependent, and hierarchic patterns of the functional necessities of its products and to avoid all the others. Since functional necessities are also slowly changing, the epigenetic system will still contain the more important interconnections or interactions of established genes of its own phylogenetic history (Riedl, 1977, p. 361).

This means that the information gaining/processing of an organism has two levels. First, there is information which gets lodged in the genome. Second, there is the information within the nervous system. (In humans, perhaps we move to a third level — involving the product of reflective thought. See Oeser, 1984.)

I will leave the discussion at this point, saying only that I have mentioned ideas which merit speculation. Nevertheless, speculation apart, I would emphasize that future research must concentrate also on empirical phenomena. An up-to-date epistemology is necessarily founded on empirical data drawn from various fields of biology and related disciplines. After all, why should epistemology remain merely a philosophical discipline?

CONCLUSION

I have sketched a biologically based epistemology, having important consequences for an understanding of *human* cognitive abilities and consequent knowledge claims. I am fully aware of the limitations of my ideas. Nevertheless, we must recognize that evolutionary epistemology, although it is not yet a fully fledged theory, has great potential towards an understanding of our own history. More than this: If we are able to understand our past, and if we are able to understand our development —

including the development of our cognitive apparatus — then we should be able better to plan our future.

NOTES

[1] Vollmer (1984, p. 70) distinguishes between "cognition" and "knowledge". Knowledge, he says, is the adequate reconstruction of outside structures in the subject, and cognition is the process leading to knowledge. It should be clear, however, that we cannot separate knowledge from cognition or *vice versa*.

[2] Even in the 1920's, this point was grasped by J. von Uexküll (1982).

[3] This term was coined by the psychologist Egon Brunswik, to characterize cognitive mechanisms which operate in ways similar to (but not identical with) rational mechanisms (see Lorenz, 1973).

[4] In this paper, I say nothing about attempts to build an evolutionary epistemology by drawing an *analogy* between the growth of knowledge and culture (especially science) and the evolution of organisms. My concern, rather, is with the epistemology which emerges when you take *literally* the evolution of humans. On this alternative approach, for positive sentiments, see Popper (1972) and Campbell (1974b); for criticisms, see Bartley (1976) and Ruse (1986); and for a balanced and important overview, see Hull (1982).

[5] Interestingly (and surely significantly), Bertalanffy, like Lorenz, concluded that the Kantian categories — the categories of experience and/or forms of intuition — emerge as the outcome of biological processes.

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