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From phyla to philosophy: Or the epistemological problem of sticking out one's neck.

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ABSTRACT
In this paper I want to explore the logical consequences of adopting evolution as a model of epistemological development and at the same time retaining notions of human choice and values in epistemology. Given the disparity between the passive Darwinian model and an assumption that rationality underlies conceptual development, what happens to the argument or the analogy? It may well be that accepting the biological model leads one ultimately to reject the idea that man somehow chooses to adapt both his intellectual environment and his theories to suit his needs, and has any way of judging such adaptations to be better than its predecessor, but that is a step most philosophers would not take lightly; indeed, as we shall see in this paper, Toulmin, Piaget and Popper will often take what seem to be desperate measures to preserve some notions of rationality, preference and intention in their concept of epistemological change.

Thomas Huxley[1] was right to claim one hundred years ago that the struggle for existence holds as much in the intellectual as in the physical world. A theory is a species of thinking and its right to exist is coextensive with its power of resisting extinction by its rivals. Yet he was vague as to how such a struggle took place, and there were many questions that he did not raise at all, for instance, whether the mechanisms of continuity and change in theories or other intellectual disciplines were similar to genetic trans- mission and mutation in species, and on what grounds other than mere survival the victor was decided. In this paper, I will look at some recent attempts to answer these questions, but focus mainly on the question as to whether giraffes choose to stick out their necks in the same way that persons choose to develop new hypotheses, or whether genetic inheritance of such a trait precludes any idea of choice.

On the Darwinian model our knowledge systems would evolve simply as a matter of historical accident and succeed or fail only in response to a general Weltanschauung over which any one individual had little conscious control. For Darwin's natural selection simply required that chance variations met or failed to meet the demands of the environment. While Lamarck had earlier thought that the long neck of the giraffe was an expression of its ancestor's insatiable desire to reach the highest branches of trees, Darwin had said that it was simply a matter of some giraffes being born by chance with longer necks than others, thus having a better chance of reaching food, thus surviving and perpetuating their species in much greater numbers than the short-necked variety. Neo-Darwinians, even with the help of Mendelian genetics and Hardy-Weinberg equations, still saw mutations as random, and phenotypes fitting as best they could into a generally hostile environment. Many Marxists and current sociologists of knowledge would say that such a passive or non-reflective development of knowledge is all that we can hope for.

Yet Mary Midgeley, speaking of similarities and differences between beast and man, sums up what seems to me to be a crucial difference between, say, the changes in the eating behaviour of a giraffe and the changes in the research programmes of physics, namely that while animals have the same problem of choice, they do not have our way of solving it by thinking about it.

Intelligence develops as an adaptation to deal with emotional conflicts, below which lies our rough natural structure of needs. What is special about people is their power of understanding what is going on, and using that understanding to regulate it. Imagination and conceptual thought intensify options, self-knowledge and values help us sort conflicts out.[2]

One must then ask in what sense it could be true that values and free choice could affect biological evolution. Monad, after Baldwin, suggested that choice could play a part in determining the direction of the species, but it did not involve foresight or self-consciousness, simply arising when an animal changed its environment or food preferences, as when a primitive fish "chose" to do some exploring on land, creating, as a consequence of a change in behaviour a selective pressure which was to engender the limbs of quadrupeds, the lungs of mammals.

In this paper I want to explore the logical consequences of adopting evolution as a model of epistemological development and at the same time retaining notions of human choice and values in epistemology. Given the disparity between the passive Darwinian model and an assumption that rationality underlies conceptual development, what happens to the argument or the analogy? It may well be that accepting the biological model leads one ultimately to reject the idea that man somehow chooses to adapt both his intellectual environment and his theories to suit his needs, and has any way of judging such adaptations to be better than its predecessor, but that is a step most philosophers would not take lightly; indeed, as we shall see in this paper, Toulmin, Piaget and Popper will often take what seem to be desperate measures to preserve some notions of rationality, preference and intention in their concept of epistemological change.

Stephen Toulmin

Stephen Toulmin closely follows the Darwinian model. In Human Understanding, he drew up explicit parallels between the evolution of species and the evolution of concepts. The existence of recognizable species was similar to the existence of recognizable disciplines and languages, springing up from a single source and becoming more complex and specialized as they evolved; the power of natural selection to disadvantage most novel variances so as to slow the changes in the overall character of an organic population was similar to the constraints offered by linguistic systems, institutional expectations, or methodological tools, and finally, a notion of "demands" which are most successfully "met" by the forms that outbreed their competitors is common both to species and disciplines.

The common process of human adaptation, of cultural innovations and selective perpetuation of favoured variants goes on continuously, as a social and populational process. The favoured innovations must somehow be "represented" or "encoded" in a form that makes them available for transmission to subsequent generations, whether it is the macromolecular structure of the gene, or the subtleties of human language and learning procedures by which children are trained into a form of life. And yet human choice and reasoning are crucial to cultural adaptation in a way that they are not to organic evolution. As Toulmin says:

> In fact the whole story of human adaptation, as presented from the viewpoint of an evolutionary epistemology, is a story not about the effects of mechanistic causes but rather about human actions that are performed "for reasons" - all those human selections and preferences, priorities and choices that deter- mine which procedural innovations shall survive and be perpetuated.[3]

Toulmin wants to say[4] that the zoological use of terms like “selection” and “advantage” involves an implicit metaphor of choice. He is enough of a Darwinian to admit that in biology, “adaptation” simply refers to the effectiveness with which each variant copes with the ecological demands of its niche, and “demands” embraces both the physical conditions of life - e.g. climate, soil and terrain - and other coexisting populations of living creatures - predators or prey, shade-plants or camouflage, parasites or intestinal flora. But he comes close to equivocation in this respect. On the Darwinian model, he- admits that it would be heresy to suppose that variation and selection were somehow coupled, and that the organism somehow chose in advance which adaptation would be advantageous to its survival in a certain environment. “To suppose that mutation and selection might be coupled would be to imply that the gamete would have some clairvoyant capacity to mutate, preferentially, in directions pre-adapted to the novel ecological demands which the resulting organisms are going to encounter at some later time.”[5] Here lies for him, the crucial difference between organic evolution and epistemological evolution, that conceptual variation and intellectual variation are coupled. Though the distinction between them becomes a little blurred, we are still left with the traditionally exigent dualisms of mind and matter, reasons and causes, autonomy and determinism.

It is a dualism that Toulmin can accept on neo-Kantian grounds. We can never know the world as it really is. The world exists outside our knowledge systems, and we can only know it through them. And yet because human actions are carried out within the natural world we can keep on adjusting our representational systems in accordance with the way they fit the real world. We as a species are always operating in a historical situation with certain demands, and we create knowledge systems to meet those demands. The giraffe born with a longer neck meets a certain demand to obtain food from higher trees, which is a good adaptation as long as the food there is edible. In a changed ecological environment however, a shorter-necked variant may win out. The assumption is that knowledge is pragmatic rather than semantic, and is therefore to be judged by its usefulness rather than its accuracy.

Just as in language we should look not for the meaning but the use, so in knowledge systems, a theory is either useful or discarded. Development of theories is no longer unidirectional and irreversible, nor is it random, but it is selected by individuals and populations to be in keeping with the current shared agreements or forms of life. Part of Toulmin’s argument in Human Understanding assumes that the closed rational systems of Euclidean geometry and Newtonian mechanics do not suit current requirements of a rapidly changing and varying ecology, both intellectual and physical, and that the notion of rationality as a forum of reason is an open-ended rewriting of old notions, a new variant.

It may have been misleading to use active verbs in the penultimate paragraph. For Toulmin, the decision to revise a concept of rationality cannot simply be made by an individual. The whole is always more than the sum of its parts, and the populational enterprise will decide whether the whim of any individual is worth pursuing. To this extent he is true to his Wittgensteinian commitment. An individual is free to use language as he pleases, but it will not do him much good in a society unless he can persuade other members to accept his forms of life. For an enterprise to be rational, it must meet these criteria[6]: a) the activities involved must be organised around and directed towards a specific and realistic set of agreed collective ideals; b) these ideals impose corresponding demands upon those who commit themselves to the professional pursuit of the activities concerned; c) the resulting discussions provide disciplinary loci for the production of “reasons”, or ‘justifications’; d) professional forums are developed to employ and monitor justificatory procedures. As in modern ecology, the systems are holistic and integral. It is positively misleading to isolate particular features for individual attention without taking the whole system into account.

There are problems with this, especially the problem of defining any- thing with any clarity or precision. For example, from the above criteria it is unclear as to whether a diffuse enterprise such as biology or medicine is as acceptable as more coherently rationalized one such as physics or chemistry. Diffuse disciplines conform only loosely to the requirements of rationality, and there are some "would-be disciplines" such as psychology, sociology or anthropology which might in principle become fields for disciplinary cultivation, but are currently ill-defined. But Toulmin can always shrug his shoulders at this and say that the same problem occurs in trying to distinguish a variation from a species, that some just are more clearly delineated than others, and that borderline cases are always fuzzy, though they may have the potential to become more clearly defined before they die out. Indeed, as in biological species, increased specialization may or may not ensure the success of the species. The problem of definition is pertinent to our current concerns only for the following reason.

So far, Toulmin has been comparing evolution of knowledge with evolution of species on almost a parallel basis, as if they were two completely separate systems, with apparent likenesses. There is a difference however that he remains unclear about. In conceptual evolution, Toulmin cannot say what the individual of the discipline is that bears responsibility for changing it from a would-be discipline to a compact one, where rationality is both the generic species and one of the agents of change. In biology, it is the giraffe who transmits the genes which may change it from a short-necked to a long-necked variation, no matter how varied the ecological variations. In a discipline, is the giraffe-gene-equivalent the researcher, concept, proposition, aims of the researchers, or all or none of these?

It doesn't help much to be told[7] that every concept is an intellectual micro-institution, if we have just been told[8] that we might look for the criteria of a discipline in a specific content, or theories, or conceptual systems. For if we tried to locate them in any one of these, we would mistake the part for the whole which also includes the researchers, the institutions, the technologies.

> The difficulty is to know which of these various strands had the deepest significance; at whether, like the fibres of a rope, they are collectively definitive of the science, without any one of them being indispensable.[9]

The creative autonomy of any one individual cannot be easily disentangled from the ecological situation which has helped to shape him and his ideas. Variation and selection are impossible to separate out in that demands dictate both change and continuity. As I said, this is not true of biological evolution if the Darwinian model is accepted. There is a plain rule: the immediate individual bodily effects of functioning cannot impinge upon individual genetic coding. While the gene pool of the population is subject to change under a natural selection which will recognise differences, especially differences in ability to achieve more adaptive functions, there is a barrier which protects the gene system from too rapid change under possibly capricious environmental demands. But as Bateson remarks:

> In cultures and social systems and great universities there is no equivalent barrier. Innovations become irreversibly adopted into the ongoing system without being tested for long-term viability; and necessary changes are resisted by the core of conservative individuals without any assurance that these particular changes are the ones to resist.[10]

Toulmin's rationality criteria show that while genetic mutation and ecological selection are decoupled, conceptual variation and rational selection are coupled. This coupling does not mean, pace Lakatos, that the systems are closed or viciously circular - Toulmin does not have the homeostatic social systems proposed by Durkheim or Talcott Parsons in mind - the mere fact that novelties have become established in the past shows that the systems are open, but he is still left with the problem of the inapplicability of coupled variation selection to epistemological variation. A metaphor roughly describes something (the principal subject, her epistemology) in terms h t are normally not predicated of it but of something else, namely he subsidiary subject, here evolution. Acknowledging that he was using Darwinian theory as a metaphor, he inverts it, exchanging principal and subsidiary subjects so that instead of viewing epistemological change from the point of view of traditional biology, he tries to persuade us that we develop d the Darwinian theory because we had already tacitly accepted a broader notion of evolutionary change in concepts and disciplines.

The proper course now, he suggests is to treat “evolution” as a general term which covers all historical processes in which a compact but changing population is represented by successive sets of elements related by descent. On this definition organic change, cultural change, social, conceptual and linguistic change are so many different varieties of historical evolution, all of which involve genealogical relations between species, cultures, societies and so on. Subsequently we can go on to distinguish between coupled and decoupled kinds of evolution; and so recognise that Neo-Darwinist zoology gives us first and foremost, “not a general account of evolution as such, but a well-established theory about the decoupled mechanisms involved in the special case of organic evolution[11]

If this seems a slick linguistic move, we must remember that Toulmin always intended only to propose a model, a new way of seeing epistemology, and, in passing, a new way of seeing evolution. Its testability is not important to him for the world is inaccessible. If we find it useful in our social intercourse, that is, it meets our current intellectual demands, then it will survive. As an individual’s way of seeing conceptual change, he proposes his variant and waits for the forum of reason, whether a group of “expert” philosophers of science, or the community in general to adjudicate as to whether it is more fruitful. From my point of view, the revision offers no pragmatic advantages, and is weak in not considering in more detail the relations between organic and evolutionary development. But I shall leave the critical summary till the end of this essay and move to a philosopher who does consider in more detail the relationship between organic and conceptual evolution.

Jean Piaget

Piaget is all too often portrayed simply as a psychologist who has worked with children, and the biological assumptions underlying his work are often glossed over or ignored. See for instance, Rosen’s comment:

> The qualifying term genetic is not a reference to the hereditary transmission of cognitive characteristics, but refers to the individual’s own historical process in the acquisition of knowledge. The ‘genesis of knowledge’ is perhaps a phrase which aptly captures the appropriate meaning.”[12]

I believe that Piaget’s primary agenda was to revise the traditional Darwinian notion to show that selection took place endogenously as well as exogenously, and that behaviour could affect future gene stock in a non-Lamarckian way, and that his experiments with children were simply a means of trying to find evidence of generic functions which had evolved as a result of evolutionary processes over time. Whether he was successful or not, time alone can tell but his genetic epistemology is certainly a programme rooted in the biological world. He insisted that neither empiricists nor innatists could account for the emergence of intelligence from instinct. In the field of knowledge for example, logico-mathematic structures were neither performed to the poi t of being completed structures within the individual (a view consistent with the Darwinian and Kantian model) nor drawn from the surrounding environment (as Lamarck and Hume had seemed to suggest).

> In their initial stages they presuppose a whole plane of actions upon objects and of experiences in the course of which objects are indispensable. However, this does not mean that such structures are drawn from the objects themselves, for they are built up by means of operational abstract elements from the actions of the subject upon objects, not from the objects themselves, ?swell as from coordinations among actions, which are progressive and necessary from the start.[13]

For the mechanisms of this organising and regulatory function, Piaget first used the evolutionary synthesis proposed by Dobzhansky and Waddington. It was not only holistic, as Toulmin’s model had been, relying on negative feedback systems outlined by McCullough and Weiner, but it. was hierarchical. Four main subsystems, each containing its own regulations, were inextricably linked by an overall system of cybernetic circuits. The genetic system is linked to the epigenetic system by a collection of feedback circuits, which in turn controls the utilization of the environment, while partially dependent on it, since environment intervenes in the formation of the phenotype. The fourth subsystem, the actions of natural selection, is directed exclusively to the phenotype, but will react in the course of successive generations by mean of genetic regroupings. In Behaviour and Evolution Piaget said that Waddington had not been explicit enough about the relation between the genotypic and phenotypic systems, saying that it was not clear whether phenotypic traits were determined by the genome, or merely compatible with the action of the genes but equally influenced by the environment. Because many phenotypes clearly selected give rise to no genotypical fixation, Piaget opts for the weaker alternative, and, using Weiss's argument against simple linear causality simply links the epigenetic system to the genome.

Weiss had claimed that the system had a capacity to respond to an exogenous change in a state of equilibrium by an endogenous reaction tending to produce a fresh equilibrium. His system was thus more open than Waddington's had been, because for him genes did not act fully autonomously but interacted and reacted on contact with the epigenetic system. Weiss also, like Piaget, generalized his model to higher cognitive activity, in an article called "The Living System: Determinism Stratified".[14] For once a two-way link between epigenes and genes is made possible, then knowledge learned over one generation have consequences for future generations. Piaget introduces the notion of phenocopy to explain how modifications can be brought about within epigenetic synthesis by phenotypical acquisition of new modes of behaviour, such modifications being- brought about by the combined effects of environmental influence and the organism's own activity. Changes may affect only organs and thus give rise to no significant conflicts to the hereditary programming of the species. But where changes work at a more primitive level, sufficient disequilibrium may be set up between epigenetic programming and genetic programming to instigate phenocopy. Note that it is the disequilibrium that constitutes the causal actor, not coded message indicating what is happening, but only that something is not functioning normally. The genome reacts by trying out variations, semi-random but very likely canalized towards the areas of disequilibrium; more like a trial than random variation.

It still remains to show that equilibrated circuits could operate in an open system, and in what way concept formation is linked with sensory systems, and I will spend some time detailing the biological argument, assuming the reader's greater familiarity with Piaget's psychological assumptions.

Behaviour is a key concept for both Weiss and Piaget. It does not connote the passive mechanism of that proposed by the sociobiologists - Piaget defined it as "all action directed by organisms towards the outside world in order to change conditions therein or to change their own situation in relation to these surroundings."[15] (On these criteria he excludes the contraction of muscles, the action of respiration or the circulation of the blood, but includes an animal's reflexes, the reactions of a flower to light, and perceptions and ideational internalizations.)

How does he use behaviour to make the genesis of knowledge genetic? Genes provide (a) hereditary programming of the content of behaviour, (b) general coordinations such as the sequential order of actions and overlapping of schema (assimilation or grouping), and (c) individual adjustments to a variety of circumstances (accommodation or groping).

There are several levels at which one's groupings can effect the groupings which had initially directed the groupings in the first place. At a very primitive level of behaviour, available even to plants, as we shall see, a physiological feedback can effect the transition from a repeated sequence to anticipations associated with corrective measures. This leads to generalization, where a form of specific behaviour is used for new purposes in a new situation. For example, sleep, which at first has a restorative function in relation to the intoxications which produce it, then becomes an anticipatory precaution against such excessive fatigue. At a slightly different level, it may become part of the hibernation instincts, protecting the animal from undernourishment as well as intoxication.

When a type of behaviour calls for the coordination of several factors a third general process comes into play, an extrinsic combinatorial system that links these elements up in various ways, as in the multiple variations of spiders' webs and cricket-chirpings - even the functional variations in beaks of finches.[16] These may result from mutations of particular genes in the Darwinian sense, but they may also be the outcome of new links between genes which remain unmodified but which have hitherto had no direct relationship. Piaget's recombination is novel in that it is not natural selection operating on simultaneously available variations, but is a selection process operating at a genetic level, the coupling of biological variation and selection that Toulmin had thought impossible. This combinatorial system is extended by a fourth, more complex intrinsic process embodying differentiations and integrations as between subsystems involving meaningful implication. Piaget uses Tinbergens work on kittiwakes to illustrate this. Kittiwakes nest on steep cliffs. Unlike other gull species, the adults do not attack predators and they defecate around the nest despite the clearly apparent white ring which the habit produces. They make no effort to camouflage eggs or young. The young do not run at their parent's alarm calls, so avoiding falls in panic. They do not fight among themselves over food but discourage competitors in this domain by means of characteristic neck motions. The establishment of this set of behaviour would be highly improbable by natural selection alone - Piaget concludes that it must require initial learning and phenocopy mechanisms.

In these processes, the corrective regulations are part of natural mechanisms, but the fifth process brings compensatory mechanisms into the picture. This is found even in plants - Piaget recounts how the sedum amplexicaule which has a lower tolerance for heat than other members of the sedum genus, dries up completely in the hot season, loses its leaves and takes on the dessicated appearance of a dead plant. However in autumn, new leaves appear, the plant becomes green again, and in spring the plant is much larger than the summer's relic. His favourite example of the increase in chlorophyll in sedum sediforme when it has to adapt to shadier environments is also an example of hereditary compensation. When one protests that plants cannot be said to "behave" because they can initiate no action in the environment as we know it, Piaget concedes that plants have neither motorlocomotive ability, nor nervous system, nor direct action upon the environment, but that they can act upon themselves, seeking thereby to strengthen or establish vital links with the environment. Indeed, Piaget claims that these limitations on their behaviour constitute a negative verification of his emphasis on the importance of behaviour, in that they are correlated with a relative paucity of hierarchical and evolutionary progress. In all of his examples determination by chance mutations is even less plausible than the notion of behaviour as teleological action directed towards the environment which can shape future genes, The sixth process operates on a principle of complementary reinforcement, where there is a phylogenetically progressive formation of certain organs intimately bound up with behaviour, such as legs, while the seventh similarly tends to fill gaps by supplying a complementary formation, the novelty of which creates very serious problems for the Darwinist, because it requires detailed information of the environment, as in the production of stinging organs or toxic substances, as in jellyfish or nettles.

All these processes - anticipations, generalizations, combinatorial systems, compensations and complementary constructions generating new structures - correspond to the basic procedures of human intelligence. Piaget has succeeded in suggesting that these similarities in the organic world, even of plants, variation and selection may not be as decoupled as Darwin and Toulmin had supposed. But the similarities should not make us blind to differences that may be crucial. In conceptual development it is the individual who is subjected to his problems, who chooses or invents them, whereas the biological adaptations we have been calling anticipations etc., cannot be categorised as intelligence because they are not intentionally organised and used by an individual with a specific new solution in view. A strong case has been presented here for a "logic of organs" from which instincts may be seen to derive, prior to the emergence of the logic of actions characterising the levels of sensori-motor acquisitions and a fortiori are in advance of the logic of concepts specific to the higher forms of intelligence. But we have not yet provided the argument needed to show how intelligence arises from instinct without being determined by it.

Let us accept pro tern the notion of phenocopy in which the genotype can be affected by the phenotype. What is the equivalent of the phenocopy in cognition? Piaget claims that there is a dynamic insomorphism between neuronal actions and a Boolean network, but that does not mean that our mathematical structures are innate. They must be built up from our behaviour, which was defined in terms of our intentional actions on the external world.

We use the same principles of feedback as those organisms we have spoken about in such detail, namely anticipations, generalizations, combinatorial systems, compensations and so on by an interactive process of grouping and groping. But the feedback in the case of the development of knowledge does not go as far back as the genome, which is why in each generation we have to spend at least twelve years of our lives individually reconstructing the logico-mathematical structure. Given the hierarchical nature of Weiss's systems, it can affect the epigenetic system, but not the essentially stable genetic structure itself. However, the interactive process requires that we cannot act upon the world without some form of coordinations of actions, and these stem from the genetic code, even at the basic level of schemes of action, such as sucking. Moreover, these need not only operate at the instinctive struggle to survive, but also an innate desire to reconstruct one's own systems in order to expand the scope of one's environment, what he called in Biology and Knowledge[17] "convergent reconstructionism and extension", a restless seeking out and conquest of new territory by virtue of a general need to feed the innate scheme of action. That may well be a. result of what Waddington had called "genetic assimilation", an earlier phenocopy which influenced our current genetic structures, though I'd facetiously suggest looking around in some of our classrooms that it is no longer a trait which the school environment encourages!

Remember that the phenocopy in its organic form comes into operation in cases where a new external environment demands new adaptations which extend beyond the epigenetic system back into the genetic structure itself. In the development of modified internal structures of knowledge, there is no chance to touch the genetic structure; indeed, the spiral that Piaget uses to illustrate the development of knowledge[18] suggests that as knowledge develops it moves further and further away from its physical and biological origins, in its most pure forms rarely referring back to the external world for trials, but by a process of emergent stages being able to "act" from an endogenous level upon a lower endogenous level, a reflexive reconstruction of form on form. The process of abstraction and representation is again hierarchical so that it is one thing to coordinate a sequence of movements, orienting each of them in accordance with equally sequential perceptual indices, as when we rotate a cube; it is quite another to coordinate the representations of these movements into a simultaneous whole without actually having to carry them out, as when we can imagine the reverse side of a cube when only its usual aspect can be seen. That the first is a requirement for the second is shewn by the recorded experiences of blind people who may have handled cubes, but cannot understand the two-dimensional representation of them when they regain their sight, because, apparently they have not a visual representation formed through their tactile experiences with the cubes. Yet it seems stretching a point, and even playing on the etymology of the term, to say as Piaget does, that the initial action and the final representation are both endogenous, in that they arise from the subject's internal schemata, and it seems a far cry from his discussions of the need to replace the exogenous by the endogenous in the biological world. On the cognitive plane, exogenous knowledge is derived from physical experience; endogenous knowledge is due to a logico-mathematical construction, and these purely endogenous coordinations therefore are called pseudo-phenocopies.[19] Piaget's aware of the distinctions I have been making between endogenous development of cognitive and biological structures in Adaptation and Intelligence.[20] He admits that the group or lattice (combinatorial) structures used by a knowing person are not genetic, and are capable of hereditary transmission only through language and learned behaviour, even then being acquired during a long epigenetic development.

He still wants to preserve what has turned out to be little more than a model because the replacement of the exogenous by the endogenous in both biological and cognitive evolution reveals that initial exogenous knowledge is largely influenced by actions on the outside world, but that the sophisticated endogenous reconstructions introduce an element of greater stability characteristic of genetic variations. Ironically, for all his emphasis on the need for interaction with the physical world at the early stages of cognitive development, he ends with a view very similar in this respect to that of Toulmin, namely that there is no exogenous knowledge except that which is grasped as content by way of forms which are endogenous in origin, whether it is the genetically transmitted need to group and grope or the constructed schemata of knowledge by which we organise our represented world. In the biological world, no phenotype is possible except as a function of the genotype, and any action of the environment is acceptable only in interaction with the synthetic processes of epigenetic development directed by the genome.

If we substitute “empirical experience” for “environment” and “endogenous forms” for “synthetic process,” the correspondence breaks down only on the essential point, that the instruments of cognitive assimilation do not extend as far back as the genome, but are directed by specifically epigenetic controls. Piaget’s argument has not shown that there is a cognitive equivalent of the phenocopy, nor that the abolition of Darwinian chance mutation makes any difference to our concept of the development of knowledge, but he has cleared the way to develop a notion of knowledge founded in an interaction between schemata and the external world as they are explored in behaviour.

I pointed out that in some odd ways he reached a conclusion similar to Toulmin’s in noting our inability to see the world as it really is, but to be able to act in it only according to our schemata and modified schemata. On one point however he diverges from Toulmin quite dramatically. Where Piaget sees the increasing stability of increasing pure logico-mathematical constructions as a progressive move, Toulmin had described them as representing a stability that could be counterproductive in the survival of knowledge systems, especially where they lost too much contact with physical interactions in the real world. Such a difference in individual valuing of stability will lead to different explorations and modifications of their own theories or forms of life, illustrating in what way values can internally select future cognitive and conceptual changes. The place of such preference in preselecting future directions of change, both biological and cognitive is discussed in the evolutionary epistemology of Sir Karl Popper, whose views on the place. of logic and testability provide a via media between the two positions I have been presenting.

Sir Karl Popper

Popper consistently describes himself as a Darwinian, even though he believes he has reconciled natural selection with the Lamarckian view that an animal’s preferences or aims can influence its evolution. He uses Baldwin’s theory of organic evolution in which all organisms, but especially the higher organisms, have a more or less varied behavioural repertoire at their disposal. Where an animal adopts a preference for a new food consciously, as a result of trial and error, it changes its environment to the extent that new aspects of the environment take on a new ecological significance. By this individual action, the organism exposes itself and its descendants to a new set of selection pressures , thus indirectly influencing the outcome of natural selection.

He is so much a Darwinian that he claims to be presenting a definition of Darwin’s natural selection with the following four curiously Popperian principles[21]:

a) the theory of natural selection is the only theory known at present which can explain the emergence of purposeful processes in the world, and especially the higher forms of life;
b) natural selection is concerned with physical survival (with the frequency distribution of competing genes in a population), and is thus concerned with the explanation of physical effects;

c) if natural selection is to account for the emergence of the domain of subjective or mental experiences (World 2) the theory must explain the manner in which the evolution of World 2 (and World 3, the world of cultural institutions) systematically provides us with the instruments for survival.
d) Any explanation in terms of natural selection is partial and incomplete. For it must always assume the existence of many (and of partly unknown) competing mutations, and of a variety of (partly unknown) selection pressures.

He had foreshadowed such an acceptance of natural selection in Objective Knowledge when he said:

> The growth of our knowledge is the result of a process closely resembling what Darwin called 'natural selection'; that is; the natural selection of hypotheses; our knowledge consists, at every moment, of those hypotheses which have shown their (comparative) fitness by surviving so far in their struggle for existence; a competitive struggle which eliminates those hypotheses which are unfit.
>
> This interpretation may be applied to animal knowledge, prescientific knowledge and to scientific knowledge. What is peculiar to scientific knowledge is this, that the struggle for existence is made harder by the conscious and systematic criticism of our theories. Thus while animal knowledge and prescientific knowledge grow mainly through the elimination of those holding the unfit hypotheses, scientific criticism often makes our theories perish in our stead, eliminating our mistaken belief before such beliefs lead to our own elimination.[22]

Trial and error hypotheses presuppose some goal, ill-defined though it may be, and in many respects, Popper's emphasis on problem-solving as the common link between the evolution of animals and our theories is similar in its assumption of purposeful action to Piaget's stipulative definition of 'behaviour', especially as problem-solving, proceeding always by the method of trial and error and error-elimination, is a constant activity for all organisms from the amoeba to Einstein. Admitting that Einstein's consciously critical attitude to his own ideas seems millennia away from the amoeba's lack of awareness of its problems as problems, Popper still claims that the difference between the two is one of degree rather than kind - especially as all organisms have inborn dispositions or preferences on which they base their active problem-solving conjectures and refutations. This is not a Lamarckian teleology. Instinctive preferences make all organisms problem-solving, but this is not the same as end-persuing. The problems of organisms are not physical, but they are specifics biological realities, like the function of an eye as opposed to the mere existence of it, something which is neither random nor deterministic.

Because such "problems" can change the world in an open-ended way, higher forms of life can emerge from the lower. Animals and man share symptomatic and signalling functions but man has developed critical awareness through the descriptive and argumentative functions of language, a function which it is still possible in principle for lower forms of life to adopt. With Popper's blessing, Donald Campbell has elaborated a nested hierarchy of selective retention processes, error-eliminating controls which can eliminate errors without killing the organism, ranging from nonmnemonic problem-solving of a hungry paramecium, to vicarious locomotor devices such as vision or radar, socially vicarious exploration such as learning and imitation, language, cultural cumulation and science above all, weeding out deleterious intellectual mutations through exsomatic experiment and quantified prediction.

To what extent is this Darwinian? Although the preference that leads organisms to choose new environments exerts an internal selection pressure, yet the process of variation is still decoupled from that of selection, a decoupling he will maintain. The actions, preferences and choices of the giraffe's ancestors played a decisive role in its evolution, because they created a new environment for its descendants, and these new external selection pressures led to the selection of long necks. But now we can catch Popper out in what seems to be a contradiction. He is Darwinian in that anatomical genes can only be changed by external selection pressures and even that habits or preferences may thus lead to changed physical structures. But when one asks where the habits or preferences come from, he has an original solution. He proposes that there are two basic classes of genes, those that control the anatomy and those that control behaviour. The latter may be divided into preference-genes and skill-genes, and it is the preference-genes that for Popper modify the behaviour that leads to the natural selection of anatomical and skill genes. In what must be a fairly complicated genetic structure, preference-genes can modify skill-genes which can eventually modify anatomy genes through the process of natural selection. When habits change, they are part of what Popper calls "organic evolution" after Baldwin. It is difficult to see on what grounds he would want to defend feedback "preference" systems which can modify the genetic structure in a way that is impossible for anatomy-genes. And yet it seems necessary for his whole theory of the three war lds. This is indeed a restatement of the Darwinian theory which amounts to a rewriting of it; Popper says that:

> evolutionary changes that start with new behaviour patterns - with new preferences, new purposes of the animal - not only make many adaptations better understandable, but they reinvest the animal's subjective aims and purposes with an evolutionary significance. Moreover the theory of organic evolution makes it understandable that the mechanism of natural selection becomes more efficient when there is a greater behavioral repertoire available. Thus it shows the selective value of a certain innate behavioural freedom - as opposed to behavioural rigidity which must make it more difficult for natural selection to produce new adaptations. And it may make it understandable how the human mind emerged… We could say that in choosing to speak, and so to take interest in speech, man has chosen to evolve his brain and his mind; that language, once created, exerted the selection pressure under which emerged the human brain and the consciousness of self.[23]

This is surely no orthodox Darwinian theory, even if it is compatible with it. It seems a little desperate for Popper to say that

> I want to emphasise how little is said by saying that the mind is an emergent product of the brain. It has practically no explanatory value, and it hardly amounts to more than putting a question mark at a certain place in human evolution. Nevertheless, I think that this is all which, from a Darwinian point of view, we can say about it.[24]

If it is so unimportant then we must ask why he has built so vast an edifice around it. It is necessary for a person who wrote The Poverty of Historicism to place some open-ended system in the genetic structure, but is it simply conservatism that makes him decide on an "organic" hypothesised preference-genetic-system rather than an organic anatomical one? And would not Darwinian natural selection, even at the risk of eliminating rational choice, have provided an adequate basis for open-ended evolutionary process? But Popper needs to strengthen the links between cognitive change and biological adaptation, and he has chosen a means of doing it which favours decisions over passive natural selection.

One of the main problems with the notion of simply random mutations which then struggle against a passive environment is that it limits the notion of progress merely to those who survive. The notion of progress is a purely relativistic one which is defined only in terms of the current ecological environment, a point which Toulmin states repeatedly applies to knowledge as well as to species. Yet Popper (with Campbell) clearly has an idea of evolutionary progress which is linked to his notion that knowledge can be objective. And in that he is not a traditional Darwinian. On Darwin's model the evolutionary tree grows up from a common stem into more and more branches, later developments differentiating into highly specialized forms, each solving its own unique problems of survival as best it can. It would be consistent for Popper to claim that the development of deductive logic and the scientific method were simply tools developed for particular needs. Indeed he admits that the evolutionary tree of our tools and instruments, which include our theories and methods, looks very similar, becoming more and more specialized.

Yet he also wants to claim that the structure of our growing knowledge has a very different shape. Assuming that the direction of time points upwards "we should have to represent the tree of knowledge as springing from countless roots which grow up into the air rather than down, and which, ultimately high up, tend to unite into one common stem".[25] This integrative growth he claims arises from our desire to explain problems by means of unified theories, our desire to keep a regulative idea of a true explanation being one that corresponds to the facts. Even Piaget baulked at the idea of trying to posit an innate preference for pure forms, claiming that the progression towards logico-mathematico-schemata may be due only in part to our neuronal structures. Popper really wants to say that man's preference for deductive thought and rigorous testing is genetically acquired, having evolved to man's advantage over the past centuries. I am always a bit suspicious of any claims that such and such a tendency is in the very nature of man, and it is odd that someone with such a stated preference for testable theories should propose something as metaphysical as this.

Conclusions

I have suggested that there is a basic conflict between the passive Darwinian model of evolutionary change in species, and the assumption that man, in choosing to improve his knowledge systems, helps them to evolve. By examining three attempts to come to terms with this conflict, I claimed that Toulmin, Piaget and Popper were sometimes forced to take desperate measures to make the analogy succeed. Toulmin's analogy was always Just that, consistent with his belief that our knowledge systems had very little contact with the real world, and that we should avoid the danger of reifying our conceptual frameworks. It is not a serious crime then for him to reverse the analogy and see Darwinian theory as a subset of evolution rather than the other way round.

Piaget in trying to discover a cybernetic feedback system which will allow genetic modification on grounds other than natural selection does succeed on the biological level, but has not managed to show that knowledge schemata can be transmitted via phenocopies, despite occasional equivocation on 'endogenous knowledge'. Popper holds as far as he can to the Darwinian model, maintaining the validity of natural selection even though behaviour is affected by human and animal preferences. Yet he makes the original move of positing preference genes, and retains a notion of universal progress, with man at the top of the evolutionary scale, and science the peak of his adaptive development.

What then are the advantages of seeing things from their respective points of view? From a historical point of view we can simply look at them as examples of mutated evolutionary hypotheses, struggling for survival against the older variation of the behaviorists and sociobiologists, and wait to see whether they develop more strongly or fade away. And yet I think there are some interesting consequences for the development of epistemology. While knowledge has been traditionally viewed as a static relationship between an independent thinking subject and external reality, it was difficult to see how it could have changed over time. Each of the writers discussed here has found it more useful to see knowledge as a process involving holistic, hierarchical and interactive systems rather than a product which is transmitted as a whole, or in separate parts. I think it is important to acknowledge that while structural group order can be explained by analysis of micro-precise assemblies of individual units, in complex structures involving living or social systems, whether the venation of a leaf, growth patterns of snowflakes, the French language or the development of chemistry, there are indications of a collective order, form or design which govern a degree of unpredictability apparent in the details of ramification. The model of ecology encourages us to look at significant relationships amongst members of a population, such relationships being severed by a physical or mental separation of the components.

Moreover the instruments of ecology are behaviour patterns, ecology being a study of group behaviour in free interaction with other groups and with environment. If we are to fully understand the way knowledge evolves, it is necessary to go and look, for instance, at the way novel variations are treated in educational environments. (Toulmin has an interesting agenda to this effect in an appendix in Human Understanding, encouraging historians to take more note of the current status of certain forms of knowledge and the potential for their rigidification or growth.) At least the evolutionary model requires us to look at the mechanisms of variation and control, and to the extent which we are able to modify them, do so where applicable.

As to the question as to whether or not the giraffe chooses to stick out his neck, we may leave that to future biologists to decide. Popper and Piaget have suggested ways in which this might be so, mainly because they were convinced that if conceptual change was to be evolutionary in any more than a metaphorical sense, then there had to be a closer link between variation and selection in the biological world than Darwin had suggested. The other alternative of course is that their evolutionary approach to epistemology is misguided, which leaves us with two main alternatives: to have a closer look at the sociobiologists, or to seek an entirely new model for epistemology. For reasons which I shall have to leave for another paper, I do not think either move is appropriate.

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