The Evolution of Scientific Lineages

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1 Introduction

The fundamental dialectic of *Science as a Process* is the interaction between two narrative levels. At one level, the book is a historical narrative of one aspect of one ongoing problem in systematics - the dispute between cladists and more traditional evolutionary taxonomists and amongst the cladists themselves on the correct method of classifying species. This narrative is replete with details of the process whereby scientists promote and publish their ideas. It is an informative and somewhat 'racy' account of the rough and tumble battleground of ideas which puts the lie to the mythical ideal of the scientist as disinterested pursuer of the Truth. At the second level, Hull presents a theoretical model of the scientific process - a model which draws heavily on invoked similarities between biological and scientific change. The narrative serves as the evidence for the model. The model, in turn, helps shape the historical narrative. The triumph of Darwinism, according to Hull, is both the triumph of a particular view of nature and a particular view of the nature of science.

My remarks will focus on the theoretical model and one of its implications. I first want to situate the model as one alternative among several which loosely fit under the umbrella of 'evolutionary epistemologies.' Second, I want to explore one of the implications of Hull's model, namely, that insofar as scientific theories are [parts of] "conceptual lineages," they are "conceptual individuals." This has the rather unsettling consequence that "conceptual descent" turns out to be a more significant criterion of conceptual identity than structural similarity.

2. Evolutionary Epistemology and the Evolution of Science

Evolutionary epistemologies are broadly naturalistic approaches to the theory of knowledge which draw heavily upon evolutionary considerations to formulate models of conceptual growth.

There are two interrelated but distinct programs which go by the name "evolutionary epistemology." One is the attempt to account for the characteristics of cognitive mechanisms in animals and humans by a straightforward extension of the biological

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theory of evolution to those aspects or traits of animals which are the biological substrates of cognitive activity, e. g., their brains, sensory systems, motor systems, etc. I have labelled this the EEM (Evolution of Epistemic Mechanisms) program (see Bradie 1986). The other program attempts to account for the evolution of ideas, scientific theories and culture in general by using models and metaphors drawn from evolutionary biology. I have called this the EET (Evolution of Epistemic Theories) program. Both programs have their roots in 19th century biology and social philosophy, in the work of Darwin, Spencer, James and others. There have been a number of attempts in the intervening years to develop the programs in detail (see the bibliography and review in Campbell 1974). Much of the contemporary work in evolutionary epistemology derives from the work of Konrad Lorenz (1977, 1982), Donald Campbell (1960, 1974), Karl Popper (1968, 1972, 1976, 1978, 1984) and Stephen Toulmin (1967, 1972, 1974, 1981). Hull's concern in *Science as a Process* is with the changes in belief attendant upon human curiosity (an EET project) and not with the origin of human curiosity (an EEM project).

Although Hull wants to distance his project from the concerns of epistemologists, both traditional and evolutionary, his work is part of an ongoing lineage rooted in those concerns. It is a project inspired by the work of Toulmin.

Hull's complaint about most of what passes for evolutionary epistemology is that it tries to be "epistemology." For Hull, traditional epistemology is bankrupt and not to be emulated. On Hull's view, the contents and methods of science cannot be "justified" *a la* the aim of traditional epistemology. But evolutionary epistemologies, while in the tradition, do not necessarily address the traditional issues.

There are three possible configurations of the relationship between evolutionary and traditional epistemologies. (1) Evolutionary epistemologies might be conceived as addressing the problems posed by traditional epistemologies (justification, skepticism, the definition of "knowledge," etc.) and offering competing solutions to them. Riedl (1984) defends this position. Hull's model for the process of science does not qualify as evolutionary epistemology in this sense. (2) Evolutionary epistemology might be seen as complementary to traditional epistemology. That is, one might defend the legitimacy of traditional problems of epistemology but hold that evolutionary epistemology addresses different but complementary issues (concerning, e. g., the growth of knowledge). This appears to be Don Campbell's view. (3) Evolutionary epistemology might be seen as a successor discipline to traditional epistemology. On this reading, evolutionary epistemology does not address the questions of traditional epistemology because it deems them irrelevant or unanswerable or uninteresting. Many defenders of naturalized epistemologies fall into this camp and Hull's work also fits under this heading. In any case, Hull's model is a descendant of a selectionist model of scientific change first proposed by Stephen Toulmin.

The core thesis of Stephen Toulmin's Human Understanding is a commitment to what Toulmin considers a form of epistemological Darwinism.

> Darwin's populational theory of 'variation and natural selection' is one illustration of a more general form of historical explanation; and ... this same pattern is applicable also, on appropriate conditions, to historical entities and populations of other kinds. (Toulmin 1972, p. 135)

Science, according to Toulmin, develops in a two-step process analogous to biological evolution. At each stage in the historical development of science, a pool of compet-

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ing intellectual variants exists along with a selection process which determines which variants survive and which die out. (Toulmin 1967, p. 465)

On Hull's view, neither biological evolution nor the growth of knowledge serves as the primarily model in terms of which we are to understand the other. Hull prefers to develop a general analysis of "evolution through selection processes which applies equally to biological, social and cultural evolution." (Hull 1982, p. 275; Hull 1988) Hull's rationale for treating both biological evolution and conceptual evolution as exemplifications of some common general selectionist model is to undercut objections to selectionist accounts of conceptual change which emphasize the disanalogies between biological and conceptual change. (Hull 1988, p. 418) Although the specific mechanisms of change are not the same in the two cases (Hull 1988, p. 431) and there is no clear evidence that there is any "significant correlation between genetic and conceptual inclusive fitness," (Hull 1988, p. 282f), Hull argues that both processes are exemplifications of a single selection model.

Hull's selection model is couched in terms of "interactors" and "replicators." Selection occurs as the differential proliferation (extinction) of replicators caused by the differential proliferation (extinction) of interactors. The abstract level of analysis is an attempt to avoid the misleading implications of particular selection models couched in terms of particular entities and processes. In sexually reproducing organisms, the interactors are the organisms themselves and the replicators are their genes or alleles. But, Hull argues, single cells (paramecium splitting) and multicellular organisms which undergo fission are candidates for being replicators as well. (Hull 1988, p. 414) Lineages are historical entities which result from replication. Thus, both genes (alleles) and organisms form lineages. Species are lineages if gradualism is true. If not, then species form lineages too. Other sequences of replicating entities, e. g., the HeLa cell line, form lineages as well. On Hull's view, all the crucial players in the model (interactors, replicators and lineages) are individuals. The interactors are the most ephemeral, the replicators are more long lived and the lineages are the longest lived of all.

Conceptual selection in science is one exemplification of the general selection model. The replicators are the ideas, themes, procedures, etc. that are passed on from one generation of scientists to another. The typical interactors are the scientists themselves and the books and articles that they write and publish. Scientists interact among themselves (when they read and criticize each other's work, check results and award or withhold credit) and with nature (when they make observations or perform experiments). The scientific process, for Hull, is driven by the "interplay between curiosity, giving and receiving credit for contributions, and the mutual checking of results." (Hull 1988, p. 431) As the results of a selection process, the resulting conceptual lineages are historical individuals.

How profitable is this analysis? This is, as Hull points out, an empirical question to be decided by more detailed empirical investigation into the processes of science. In conceding that "[t]he specific mechanisms involved in biological and conceptual evolution are quite different," Hull undermines some of the initial credibility of the similarity between biological and scientific evolution. For is this not the crucial point - that the specific mechanisms are not the same? In the case of specific theories such as Newtonian mechanics, the scope of the theory is extended by incorporating new phenomenological domains under the rubric of worked out examples or Kuhnian exemplars. In such cases, the same specific mechanisms, e. g., the force of gravitation or the spring force, are in play in both the old and new domains. However, in the present case, the situation is different. Either we are arguing by analogy from the bio-

logical to the conceptual or we are arguing from some common framework to both. In either case, as Hull admits, the specific mechanisms are not the same. This raises serious questions about the explanatory virtue of such a move. How strained do the connections between the mechanisms have to become before we concede that the "sameness" of process is *mere* "similarity?" Aristotle's characterization of motion as the actualization of that which is potential brought a wide diversity of phenomena under a single rubric but it did so at a price that, from our modern perspective and interests about motion, borders on the vacuous. In one sense, all (Aristotelian) motion exhibits the "same" features although the "specific mechanisms" can be quite different. But the important aspects of different kinds of motions, at least to our contemporary way of viewing things, lies in the details and the differences. Can Hull's view provide that? Only time will tell. Hull would, no doubt, agree that much significant conceptual work needs to be done along with the empirical case studies.

3. Species and Conceptual Lineages as Individuals

One of the main messages of the book is that "species, if they are to play the roles assigned to them in evolutionary theory, must be treated as historical entities." (Hull 1988, p. 79) It follows, Hull argues, that species are individuals and not natural kinds. The correlative implication for conceptual evolution is that "[j]ust as species cannot be treated simultaneously as historical entities and as eternal and immutable natural kinds, neither can concepts." (Hull 1988, p. 17)

I want to consider two questions in this regard. First, does the fact that species are historical entities entail that they are individuals and not natural kinds? And second, how plausible is it to construe conceptual lineages as individuals?

3.1 Species as Individuals

Consider the case of the elements. They are natural kinds structurally defined. Even if all the referents for hydrogen, e.g., disappeared, that is, if all the hydrogen atoms in the universe ceased to be, a "slot" for Hydrogen would remain and any new entity created with the appropriate structure would qualify as Hydrogen. Why not the same for species? On this view we would construe the sense-species of, say, human being as eternal and if all the current referents disappeared then it would remain as a "slot" etc., etc. Hull rejects this option and claims that other Darwinians (including Charles Darwin himself) now reject it as well. The ground for rejection is that species taxa are evolving individuals that are spatio-temporally limited existents. New "humans" would not have the appropriate genealogical connections and, thus, would not count as bona fide humans. But, why is this not simply a problem of re-qualification for human status? and not something essentially related to individuality?

Suppose Jones, after an imprint matrix of his being is taken, suddenly dies. A new "Jones" is constructed with appropriate memories, preferences, desires, personality, etc., but, of course, a lapse of memory for one crucial part of "his" life. Is it the same individual or not? If "physical" continuity is crucial, no. But, physical continuity is never enough as witness cases of multiple personalities. If "psychological" continuity is crucial, perhaps it is the same person. Again, psychological continuity is not everything either as cases of amnesia illustrate.

Why not say that the 'genealogical requirement' just makes it that much harder for 'new' members to qualify as members of the club but does not necessitate that species taxa have a different ontological status from physical elements? Which comes first? Do we first note the genealogical connections and then infer species taxa are individu-

als or do we argue that since they are individuals, so the genealogical requirement must be met? Presumably the former, in which case if we can make out a case for satisfying the 'genealogical requirement' and not being an individual, then the inference from 'X is a historical entity satisfying a genealogical requirement' to 'X is an individual' will be blocked.

If, indeed, there is no difference in principle between human beings and hydrogen atoms, we should say that just as there are atom particulars and atom kinds, so there are human particulars and human kinds. It is just part of the vagaries of biological existents that they are less easily come by than their atomic counterparts. Hydrogen atoms come about "spontaneously"-they are not spawned by other Hydrogen-atoms. But, suppose spontaneous generation amongst biological organisms were more widespread than we now think it is? Wouldn't this raise problems for Hull's account? At the very least it would show the tight interconnection between metaphysical and scientific issues if a matter of fact can determine which ontological category a given entity belongs to. This reminds us that the descent and genealogical nexus of organisms is an empirical fact (or theory) about natural entities. These natural entities would still exist even if we turn out to have had fundamentally false beliefs about them.

3.1.1. A Science Fiction Fantasy in Four Scenarios and a Coda

Scenario 1: "Aristotle Redux"

Spontaneous generation is more widespread than we currently believe. The net effect is that "species" or kinds may or may not have the appropriate lineages (depending upon whether sex is obligatory or facultative).

Scenario 2: "Howdy, pardner"

The biospecies concept and the ethos of the Old West: It's bad form to ask a Stranger about his/her past. If they mind their own business and don't cause any trouble, then they're OK. The Stranger comes, woos, wins, weds, beds and fertile offspring ensue. The biospecies concept sorts individuals into different species according to whether they can (same species) or can not (different species) produce fertile offspring. Now, is Hull going to deny those children their birthright by challenging the pedigree of the Stranger? And, even if he did, wouldn't we call the Stranger "human" if it looked like, sounded like, tested out as, etc., etc., even if it didn't have the appropriate pedigree?

Scenario 3: "The Artificial Human"

Plot A: In virtue of advances in biotechnology, the parts of a "real" human being are replaced one by one with ingenious plastic substitutes which, through the miracles of modern science, work just as well as the originals. First the left thumb, then . . . Finally, the time comes for the final original part to be replaced. The new product looks like, walks like, talks like, etc.. Isn't it still human?

Plot B: As the transplantation process described above is being performed, 'baby' replicas are being assembled and maintained. At the last stage, we have a perfectly formed "human[?]" baby, capable of growth, development, etc. Suppose it does grow, develop, move west, woo, win, wed ... Isn't it human? No? Why not? Because it doesn't have the appropriate genealogical connections?? BUT, now we have to ask: is having the appropriate lineage so important as to outweigh all the other respects in which it does seem to qualify as human?

Scenario 4: "Gothian visions"

We are, alas, merely parochial existents in one bubble out of an infinity of bubble universes, each having its own 'Big Bang' and subsequent expansionist evolution. The laws of nature being what they are and the initial distributions being what they are, we need not assume that all these bubble universes will evolve in exactly the same way. Some collapse before they barely get started, others expand indefinitely, others oscillate forever. In some of those universes, an element that looks like our Hydrogen and reacts like our Hydrogen and has the 'same' structure as our Hydrogen exists. Is it Hydrogen? Natural kinds being what they are, we are supposed to say yes! But, these "Hydrogen atoms" don't share the appropriate genealogy with our Hydrogen. They didn't come from our Big Bang. Perhaps, but genealogy does not play a role for being Hydrogen like it does for being a Human Being. Aha, but that's because we didn't realize before that there was more than one universe and more than one historical lineage for elements. Now that we do know, history should make a difference, shouldn't it? If not, why not?

Why should we count the (hypothesized) ability of our Hydrogen to combine with their Hydrogen to form molecules of H_2 in such a way the two components are structurally indistinguishable as evidence that their Hydrogen really is Hydrogen while we are expected to discount the (hypothesized) ability of our human beings to mate with their "human beings" and produce fertile offspring as evidence that their "human beings" are "really" human? Is it because it is part of the meaning of "human being" (or of being a biological taxa) that its "parts" have the appropriate lineage? How true to Darwin is this? And don't we have essences back again?

Coda: "The Counterfactual Defense"

Of course, in general, Hull rejects such science fiction scenarios as philosophically irrelevant (Hull 1988, p. 28). Science and the philosophy of science are too interconnected, he holds, to allow for the relevance of "unconstrained science fiction" examples.

Hull rejects the use of contrary to fact conditionals to test conceptual limits: but philosophical claims about science, if they are to be testable [!?], must submit to empirical tests of physical possibility. Conceptual/physical possibility must be treated together and counterfactuals, to the extent they are used, must be structured within the possibilities of science as we now know it. But, aren't the scenarios described above within the bounds of the empirically possible? And don't they show that the categorical difference between lineages and kinds is not as sharp as one might suppose?

3.2. Conceptual lineages as individuals

Insofar as Hull's model takes conceptual systems to be analogous to biological species, it endorses the view that conceptual systems are evolving lineages. This has implications for the criteria of identity and individuation of conceptual systems. For species, the (evolutionary) criterion for conspecificity is descent not similarity of morphology. If we are to take the selectionist model of scientific change seriously, the criterion for being the same system or theory should be likewise descent not similarity in logical or conceptual structure. This is a radical thesis. It entails, among other things, that two individuals who hold structurally similar views but who do not share the appropriate causal nexus cannot properly be said have the same views. On the other hand, two individuals who do stand to one another in the appropriate causal relationships, but whose views may be structurally quite different, can be said to share

the same theory, program or tradition. So, "Darwinians" are not individuals grouped together because of a common core of beliefs (which would constitute the "essence" of "Darwinism" - as an individual, the lineage of "Darwinians" has no essence) but rather the "Darwinians" constitute a coterie of individuals who have learned from, and interacted with, each other in appropriate ways. At the very least, such an approach promises to reshape the intellectual landscape of the history of science. It is a very interesting way to do history and I admit to being somewhat partial to it. However, it does produce counterintuitive results. Consider a doctrine D1 put forth by a scientist S1. S1 transmits his doctrine to S2 and in the process D1 is slightly modified to become D2. Imagine this transfer to continue for some time in whatever ways are causally appropriate to preserve continuity of tradition. All the Si's can proudly claim to D-ists. Now suppose doctrine D1 has the simple structure "p" where "p" is some declarative assertion. On the grounds that descent is (almost) everything for determining lineage identity, it does not seem inconceivable that, for some Sn, the form of the doctrine espoused could be "not-p." Now I, for one, would find it extremely odd to say that both S1 (who believes "p") and Sn (who believes "not-p") are endorsing the same view or even that they can properly be said to be in the same (intellectual) tradition.2 What blocks immediate assent is the radical structural dissimilarity between the views of S1 and Sn. Of course, on Hull's view, this is not relevant if the criterion of identity is the existence of some appropriate causal chain.

We have the following situation. There is a phenomena called the "scientific process" and we have competing models put forward to account for it. On what we may call the traditional view, the criterion of conceptual individuation is structural similarity of views. Two individuals hold the "same" views just in case the views they endorse are structurally similar in relevant respects. The traditional view has in its favor the commonplace that we distinguish Believers from non-Believers in terms of whether or not they accept the existence of God, regardless of how they come to hold such beliefs. On Hull's view, the criterion of conceptual individuation is causal descent. Two individuals hold the "same" views just in case they have interacted in appropriate ways regardless of any structural dissimilarity between their respective views. This, as I have suggested, is prima facie, counterintuitive. I do not suggest it is wrong, just a bit fishy.

The question is, how is the neutral observer supposed to decide which way to go? Do the cases where structurally dissimilar views which nonetheless stand in a relation of descent count against the view of conceptual systems as lineages or is it merely some aspect of our intuitions that we need to adjust in the light of or acceptance of the truth about conceptual systems? This is an open question to defenders of the "intellectual traditions as entities" view. A correlative question is what difference does it all make? We wind up reclassifying some scientists whom we took to be Darwinians to be otherwise and some others whom we took not to be Darwinians to be so, but so what? Is there more, and if so, what is it?

4. Conclusion

The selectionist model of scientific change advanced by Hull has a number of important and problematic consequences. In section 2, I raised some questions about the appropriateness of the selectionist model for understanding scientific change. In section 3, I raised some questions about the appropriateness of the distinction between "lineages" and "natural kinds," endemic to many contemporary interpretations of Darwinian theory and proceeded to explore some of the implications of treating scientific concepts and traditions as lineages.

With respect to the question of whether scientific concepts are "lineages" or "natural kinds," I suspect there may be something to both claims. There is an ambiguity about terms like "Darwinian" (or "Newtonian," "Lamarckian," "Dadaist," etc.). On the one hand, such terms label individuals who have been appropriately influenced by the named individuals or movements. In this sense, "Christians," e. g., are those who share a relationship of "apostolic descent" to the founding fathers of the faith, regardless of the disparities of their respective beliefs. On the other hand, such terms label individuals who share structurally similar views. In this sense, individuals who never heard of Darwin or anyone who was associated with Darwin, could be called a Darwinian, given that they held relevantly similar views. With respect to the historiography of science and the taxonomy of scientific doctrines it remains to be seen which reading is most appropriate or whether there is indeed room for both. To the extent that there is room for both, concepts can be construed as both "historical entities or lineages" and "kinds" structurally defined. But, if so, and if Hull is right about the fundamental similarity between biological and conceptual evolution, then we may suspect that biological species have a mixed pedigree as well.

The distinction that Hull and others draw between ecological and evolutionary perspectives in studying species may be helpful here (Hull 1988, ch. 11). Considered from an ecological perspective, a tradition or view is a kind. Seen from an evolutionary perspective, a tradition or view is a lineage. The case where a view evolves into its negation shows that the two ways of cutting up conceptual reality do not map onto one another in a one to one fashion. This, I think is both true and an interesting observation. There is, however, the following point. Scientific views or traditions function as individuals in both perspectives. A tradition, conceived ecologically, has the power to mold and change opinions and the views of others. To the extent this is correct, it points up an important difference between traditions and species. Species function as individuals when conceived from an evolutionary point of view but they do not do so when conceived from an ecological perspective (cf. Eldredge's analysis of the dual hierarchies in Eldredge 1985).

Finally, Noretta Koertge's paper raises the question of whether Hull's view helps to solve the demarcation problem. As Hull remarks in his response, the demarcation problem, which was a central problematic of the logical empiricist and Popperian philosophies of science, is nowadays somewhat out of fashion. The onslaught of social constructivist interpretations of science in the wake of Kuhn's historicist analysis has blurred the distinction between what is science and what is not. This is not surprising. The meaning criterion of the logical empiricists, which was to serve as the demarcation principle was essentially ahistorical. Even Popper, with his emphasis on the importance of the problem of conceptual change, relied on the fundamentally ahistorical criterion of falsifiability. Hull's analysis, which focuses on the evolutionary dynamics of conceptual change, holds no promise of a quick and dirty resolution of the problem of what distinguishes science from non-science. Indeed, insofar as science stands to other intellectual traditions as one species stands to another we should not expect there to be any sharp delineation. But this brings to the fore an unresolved tension in Hull's analysis. Whereas he wants to treat particular scientific traditions as evolving, non-essentialistic individuals, he is prepared to defend the view that science, as such, has an essence (Hull 1988, ch. 2). His response to Koertge reflects this: "other sorts of conceptual change . . . [might] . . . turn out to exhibit some of the characteristics of conceptual change in science . . . [and] . . .if a sort of conceptual change turns out to have all the characteristics of science fully developed [my emphasis], then it is science, common conceptions to one side." More work needs to done in spelling out the details of Hull's conceptualization of scientific process before we can be satisfied with this.

Notes

[1]Robert Richards, in his recent book, *Darwinism and the Emergence of Evolutionary Theories of the Mind and Behavior*, reaches a similar conclusion on the basis of a selectionist model of scientific change which he calls the NSM. For a discussion of Richards's book, see Bradie (forthcoming).

[2]Consider the following dialogue: She: I believe in God. He: I do not. She: Oh, I am so glad we share the same religious tradition.

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