Discussion: Kuhn's Evolutionary Analogy in *The Structure of Scientific Revolutions* and "The Road since Structure"*

Thomas A. C. Reydon and Paul Hoyningen-Huene†

Recently, Barbara Renzi argued that Kuhn's account of scientific change is undermined by mismatches in the analogy that Kuhn supposedly draws between scientific change and biological evolution. We argue that Renzi's criticism is inadequate to Kuhn's account of scientific change, as Kuhn does not draw any precise analogy between the mechanisms of scientific change and biological evolution nor aims to argue that the mechanisms of scientific change and biological evolution are similar in any important respects. Therefore, pointing to mismatches between the central concepts that feature in the descriptions of the two phenomena simply misses the point of Kuhn's analogy.

1. Introduction. In a recent article in this journal, Barbara Renzi (2009) argued that the account of scientific change that Kuhn presented in *The Structure of Scientific Revolutions* (*SSR*; Kuhn 1970) and "The Road since Structure" (RSS; Kuhn 1991) is flawed. According to Renzi, Kuhn's account is undermined by mismatches in the analogy that Kuhn draws between scientific change and biological evolution.[1]

In a nutshell, Renzi's argument goes as follows: Kuhn claims that the process of scientific change is analogous to the process of biological evolution. But if this claim is correct, then the central concepts in Kuhn's account of the process of scientific change should match the central con-

*Received January 2010; revised January 2010.

†To contact the authors, please write to: Thomas A. C. Reydon, Leibniz Universität Hannover, Im Moore 21, D-30167 Hannover, Germany; e-mail: reydon@ww.uni-hannover.de.

1. Renzi's is not the first criticism of Kuhn's analogy between scientific change and biological evolution. An earlier criticism was, e.g., presented by Bird (2000, 211–14). Bird's criticism, however, followed a somewhat different line from Renzi's, and Renzi (2009, 147–50) explicates the differences between her argument and Bird's approach.

Philosophy of Science, 77 (July 2010) pp. 468–476. 0031-8248/2010/7703-0001$10.00

cepts in the accepted scientific description of the process of biological evolution. This is, however, not the case, as there are a number of important mismatches between the relevant concepts. Therefore, Kuhn's account of scientific change is flawed. In particular, Renzi identifies two major problems: (1) Kuhn's notion of progress does not correspond to any currently accepted notion of progress in evolutionary biology; (2) Kuhn's notion of a niche and his view of how species and their niches coevolve with the environments in which they live does not correspond to how biologists conceive of niches and the coevolution of species and their environments (Renzi 2009, 150).

We criticize Renzi's argument against Kuhn's account of scientific change. Most important, we argue that the general gist of Renzi's criticism is inadequate to the account of scientific change that is presented either in *SSR* or in RSS, as in these works Kuhn does not draw any precise analogy between the mechanism of scientific change and the mechanism of biological evolution (sec. 2). Kuhn's aim in *SSR* and RSS is not to argue that the mechanisms of scientific change and biological evolution are similar—therefore, pointing to mismatches between the central concepts that feature in the descriptions of the two phenomena simply misses the point of Kuhn's expositions in *SSR* and RSS. Even though we think this point is sufficient to defuse Renzi's criticism of Kuhn's account, we still want to examine Renzi's criticism in some more detail by taking a closer look at the above-mentioned point 1, that is, the supposed mismatch regarding notions of progress (sec. 3). We show that while Renzi's criticism on this specific point does point to a problem in Kuhn's account, it fails as a criticism of the evolutionary analogy in RSS.[2]

2. How Kuhn's Analogy Works. We want to begin by noting that if Kuhn drew the analogy between biological evolution and the evolution of science in *SSR* and RSS for expository reasons only, the discrepancies that Renzi pointed out should not be problematic for Kuhn's account. Metaphors and analogies are commonly employed to serve various functions, including didactical, rhetorical, and literary ones. Such usages usually do not carry the implication that the domains on both sides of the metaphor or analogy can be mapped onto one another. This practice is unproblematic as long as metaphors and analogies are not taken too literally—in the case under consideration, as long as it is not implied that the evolution of science and the evolution of biological populations are different instantiations of the very same process.

Renzi, however, claims that Kuhn makes precisely this latter implication

2. For reasons of space, we have to leave Renzi's point 2 for what it is.

and that, therefore, mismatches in the mapping of elements of Kuhn's account onto elements of biological evolutionary theory are fatal to Kuhn's view. According to Renzi, "Kuhn . . . introduces the evolutionary analogy with the intention of showing that this view of progress [i.e., Kuhn's account of progress in science] is defendable and tenable: it is possible and even plausible to regard science as progressive in the absence of a fixed goal because, he thinks, biological evolution is also progressive but nondirected" (2009, 145). Indeed, Renzi explicates, "Kuhn's passage [from *SSR*] shows that, in science, *a mechanism analogous to biological evolution is in place* that accounts for the adaptation of our knowledge and practices to the problem-solving activity" (146; emphasis added).[3] Here, Renzi interprets Kuhn's argument as saying that (1) the actual mechanisms by which scientific change and biological evolution occur are very similar and (2) biological evolution is progressive while not being goal directed, such that (3) therefore it is plausible that scientific change is also progressive while not being goal directed.

This is, however, a misrepresentation Kuhn's argument. While Kuhn does endorse premise 2 and aims to establish claim 3, he does not endorse premise 1. In fact, in *SSR* and RSS Kuhn does not even use the biological analogy in the context of an *argument*—rather, he uses it in the context of an *exposition*. The role of the biological analogy is not to highlight far-reaching similarities between the mechanisms of scientific change and biological evolution and on this basis to argue that if biological evolution is a progressive but not goal-directed process, scientific change (as a process highly similar to biological evolution) too is progressive but not goal directed. Kuhn uses the analogy for expository reasons only, namely, to show that the novel notion of scientific progress as not directed at a preset goal (truth) that he introduces is not internally inconsistent (cf. Hoyningen-Huene 1993, 262).

Basically, what Kuhn wants to achieve is to convince the reader that it is possible to conceive of processes that are progressive while not being aimed at any preset goal. To be sure, this is not self-evident: normally when we think of progress we conceive of progress toward some envisaged goal (as someone can make progress on his way to reducing his weight below a given value set by his doctor). According to Kuhn, however, science is progressive without there being any goal (e.g., truth) toward which science progresses. Kuhn thus has to show that we can think of

3. Renzi even speaks of a "complete analogy" (2009, 147) that Kuhn supposedly draws between the mechanism of scientific change and the mechanism of biological evolution and of "Kuhn's account of a 'Darwinian' progress in the development of science" (150). It thus seems clear that Renzi thinks that Kuhn held that the two mechanisms were highly similar if not identical.

progress in a different way from progress toward a goal. Kuhn's strategy, then, is to point to one such process of non-goal-directed progress that actually exists in nature—biological evolution—and to suggest that if non-goal-directed progress is realized in nature, it is not in principle impossible for science to be progressive in a non-goal-directed way too. In order to achieve his goal, Kuhn does not need to show that biological and scientific evolution both proceed by largely or partly the same mechanism—nor does he in fact attempt to show this.

The expository role of Kuhn's evolutionary analogy is particularly clear in *SSR*. The relevant parts of *SSR* (from chap. 13) are these:

> It helps to recognize that *the conceptual transformation here recommended is very close to one that the West undertook just a century ago*. It is particularly helpful because *in both cases the main obstacle to transposition is the same*. When Darwin first published his theory of evolution by natural selection in 1859, what most bothered many professionals was . . . [a] difficulty [that] stemmed from an idea that was more nearly Darwin's own. All the well-known pre-Darwinian evolutionary theories . . . had taken evolution to be a goal-directed process. . . . For many men the abolition of that teleological kind of evolution was the most significant and least palatable of Darwin's suggestions. . . . What could "evolution," "development," and "progress" mean in the absence of a specified goal? To many people, such terms suddenly seemed self-contradictory. (1970, 171–72; emphasis added)

The analogy that Kuhn draws in this quotation is not between the mechanisms of biological evolution and scientific change. Rather, it is between the conceptual transformation that occurred in the transition from pre-Darwinian evolutionary theories to Darwin's theory and the conceptual transformation involved in the transition from pre-Kuhnian accounts of scientific change to Kuhn's account. Both theoretical transitions involve a conceptual change from a notion of progress that is wedded to goal directedness to a notion of progress decoupled from teleology. And both conceptual transitions are confronted with the same conceptual difficulties for the same reasons.

That Kuhn sees the analogy as limited to the conceptual change involved in the two cases of transition between theories and not as involving similarities on the mechanism level, can be seen from the following quotation: "The analogy that relates the evolution of organisms to the evolution of scientific ideas can easily be pushed too far. But *with respect to the issues of this closing section* it is very nearly perfect. The process described in Section XII . . . may have occurred, as we now suppose biological evolution did, without benefit of a set goal, a permanent fixed

truth" (1970, 172–73; emphasis added). The "issues of this closing section" that Kuhn refers to are issues related to conceptual change between different theories of scientific change, not issues relating to the actual mechanism of scientific change, as this is not a topic of discussion in that section of *SSR*.

Although the evolutionary analogy in RSS is put in somewhat stronger terms than in *SSR*, also in RSS Kuhn nowhere writes that he wants to establish a full analogy between the mechanism of scientific change and the mechanism of biological evolution. In RSS, Kuhn merely draws three parallels between the scientific and the biological case. First, "scientific development must be seen as a process driven from behind, not pulled from ahead—as evolution from, rather than evolution towards" (1991, 7). This is the analogy that is also drawn in *SSR*. Second, scientific revolutions are like speciation events in biological evolution (8). Third, in both biological evolution and scientific change, the unit that undergoes speciation is not the individual organism but a "population" of organisms, in the biological case "a reproductively isolated population" and in the scientific case "a community of intercommunicating specialists" (8). Thus, notwithstanding the suggestive terminology that Kuhn uses, also in RSS Kuhn does not argue that the two mechanisms are instantiations of the same basic mechanism, nor does he argue that the two mechanisms operate in largely similar ways. He merely highlights three points on which scientific change and biological evolution resemble one another: in both processes progress consists in evolution away from the present state, and in both processes speciation events occur in which existing populations split up into two descendant populations.

In our view, thus, Renzi misinterprets Kuhn's evolutionary analogy as being about similar mechanisms rather than about similar problems in cases of theory change (as it actually is). Consequently, Renzi's general criticism fundamentally misses the point of Kuhn's analogy. We now turn to a specific point of criticism that Renzi advances against Kuhn's analogy as it is developed in *SSR* and RSS, namely, a criticism of the first of the three parallels discussed above.

3. Progress. Renzi's specific attack on Kuhn's account of scientific change has two fronts. First, "Kuhn's notion of progress in evolutionary biology is oversimplified and does not coincide with the notion currently accepted by evolutionary biologists" (Renzi 2009, 150). Second, "the more articulate account of scientific change exposed in RSS is based again on a more general misunderstanding of the biological side of Kuhn's analogy, namely the notion of ecological niche and related concepts" (150). For reasons of space, we only consider Renzi's first point and show that, while correct, it fails as a criticism of Kuhn's analogy.

Renzi correctly points out that there are at least two distinct notions of progress in evolution.[4] One, which Renzi calls "local progress," represents the idea that individual species (or better: populations) can reach stages of increased adaptation as a consequence of natural selection. The other, which Renzi calls "global progress," reflects the idea that as evolution proceeds life forms come into existence that are more complex than the already-existing ones, such that evolution as a whole progresses toward more complex life forms. While local progress is evolutionary progress of individual species, global progress involves progress on the level of the whole of life on Earth.

According to Renzi (2009, 151), "Kuhn blurs this distinction between 'local' and 'global' progress and associates the articulation of disciplines (complexification) to their increased local success (adaptation)." That is, Renzi reads Kuhn as holding a view on which the global "complexification" of science (by means of the coming into being of new disciplines that are more complex than the already existing ones) and the local "adaptation" of individual disciplines go hand in hand. Renzi agrees with this view of science. On her view, "if we represent our disciplinary scientific knowledge as a taxonomy of concepts, higher success in problem-solving can be *only* achieved when the taxonomy gets more complex, populated by more concepts and in new relations with each other" (151; emphasis added). But, although Renzi agrees with Kuhn's view of science on this point, she argues that this presumed fact of the matter about science points to an important disanalogy between Kuhn's view of the evolution of science and biological evolution. In biological evolution, "adaptation is uncoupled from specialization and species can lose complexity over time" (151) while still reaching increased levels of adaptedness.[5]

4. See Rosenberg and McShea (2008, chap. 5) for an in-depth discussion of the various notions of progress in biology.

5. In this part of her argument, Renzi makes a notable mistake. First, she cites literature from the philosophy of biology saying that descendant species may become less complex than their immediate ancestors (which is correct). She then writes that this should not be surprising "if we think that some species, such as our own, are now highly complex while many others, such as most bacteria, have never increased their complexity" (2009, 152). But the latter fact—there being more and less complex species in existence today—does not show that individual species may lose complexity in evolution. It merely shows that some lineages have increased more in complexity than have others. Here, Renzi herself seems to conflate the local and global notions of progress. Of course, in the background of this entire discussion stands the assumption that we have a fairly clear notion of what exactly is meant by the complexity of a species (or, more accurately, of the organisms of a species). This is, however, not so. We shall not address this issue here, but for an overview of what can be meant with organismal complexity and an argument (supporting Renzi) that the evidence for the claim that complexity in fact does increase in evolution is weak, see McShea (1991) and Rosenberg and McShea (2008, 22, 127–55).

The disanalogy between this particular interpretation of Kuhn's analogy and biological evolution is clear. However, Renzi's claim that "higher success in problem-solving can be *only* achieved when the taxonomy gets more complex" does not seem warranted. The notion of complexity invoked here encompasses the number of nodes (concepts) within a discipline's network and the number of relations between them; that is, it is related to Renzi's notion of local progress and not to global progress. To be sure, increasing the number of available concepts and the number of relations between them may yield increased problem-solving power, simply because more tools are available. But there does not seem to be a reason to expect that the only way to achieve increased problem-solving power is by increasing the number of nodes and connections in the conceptual network of a discipline. Merely replacing some of the concepts and relations might in principle also do the trick, and, depending on the case at hand, it might even be the case that a less complex conceptual network works better than a more complex one. This is an issue that cannot be settled a priori by simply assuming that an increase in the number of nodes and connections in the conceptual network of a discipline is a strict requirement for increasing its problem-solving capacity.

Thus, while it is true that in biological evolution local increases in adaptedness do not necessarily go hand in hand with global progress, this does not point to a disanalogy between the evolution of scientific disciplines and biological evolution. In the evolution of disciplines, too, increases in local adaptedness (i.e., problem-solving power) do not necessarily go hand in hand with global progress.

We think that Renzi is correct in her interpretation of Kuhn as holding the view that speciation in scientific revolutions is intrinsically connected to increases in problem-solving capacities. Thus, the preceding discussion points to a problem for both Kuhn and Renzi (who, after all, agrees with this view of scientific change). However, Renzi's point does not hold against Kuhn's evolutionary analogy because to our knowledge Kuhn never claims that scientific evolution and biological evolution actually are similar in this particular respect (and he certainly does not make such a claim either in *SSR* or in RSS). That is, while Kuhn does hold that articulation of new scientific disciplines and increasing problem-solving capacities go hand in hand, he does not claim that this is in any way related to supposed similarities between the processes of scientific change and biological evolution.

4. Conclusion. Our principal claim in this article is that Renzi's general project of criticizing Kuhn's evolutionary analogy is misconceived, as Kuhn only highlights a few specific parallels between scientific and biological evolution but nowhere claims that the two are instantiations of

one and the same mechanism or even that they instantiate highly similar mechanisms.

In addition, Renzi misreads Kuhn on several minor points. For example, Renzi claims that during periods of normal science, "scientists are busy solving the puzzles arising from empirical testing of the current paradigmatic 'view of the world' of that discipline" (2009, 143). However, in Kuhn's account of science, during normal science, paradigms are not themselves subject to testing but constitute the unquestioned background of research (see Hoyningen-Huene [1993], 175–79, and the references to Kuhn given there).

Another example is Renzi's claim that in RSS Kuhn's use of the term 'world' slides from "the physical [world] that we already find in place" to "the world that we can effect or invent" (2009, 156). This is, however, also a misreading of Kuhn. In the central passage from RSS on which Renzi bases her reading of Kuhn, Kuhn writes that "the world is not invented or constructed. The creatures to whom this responsibility is imputed, in fact, find the world already in place, its rudiments at their birth and its increasingly full actuality during their educational socialization. . . . *That world*, furthermore, *has been experientially given* . . . in part indirectly, by inheritance, embodying the experience of their forebears. *As such*, it is entirely solid" (1991, 10; emphasis added). It should be clear from this passage that with 'world' Kuhn does not mean what Renzi somewhat misleadingly calls the physical world—that is, the world out there (to which in Kuhn's view humans do not have epistemic access; see Hoyningen-Huene 1993, 34–35)—but the phenomenal world that is "given" to newborns by the society into which they are born and embodies the experiences of their forebears. As such, the world is solid.[6] Renzi's claim that Kuhn silently slides from one usage of the term 'world' to another and thereby from discussing the evolution of epistemological mechanisms to discussing the evolutionary epistemology of theories (Renzi 2009, 156) thus is unfounded.

We thus conclude that Renzi's criticism fails to be adequate to Kuhn's evolutionary analogy, both with respect to the general conception of the criticism and in some of its details.

6. See Hoyningen-Huene (1993, chap. 2; 2008, 44–45) and Hoyningen-Huene and Oberheim (2009) for a discussion of Kuhn's usage of the term 'world'. In particular, see Hoyningen-Huene (1993, 34–35, 60–63; 2008, 44) and Hoyningen-Huene and Oberheim (2009, 206–8) for the point that the experientially given world that humans find already in place is not the inaccessible "world-in-itself" (Hoyningen-Huene 1993, 35; Hoyningen-Huene and Oberheim 2009, 206) but the phenomenal world that is "given" in the form of the collective experiences of a community.

REFERENCES

Bird, Alexander. 2000. *Thomas Kuhn*. Princeton, NJ: Princeton University Press.

Hoyningen-Huene, Paul. 1993. *Reconstructing Scientific Revolutions: Thomas S. Kuhn's Philosophy of Science*. Chicago: University of Chicago Press.

———. 2008. "Commentary on Bird's Paper." In *Rethinking Scientific Change and Theory Comparison: Stabilities, Ruptures, Incommensurabilities?* ed. Léna Soler, Howard Sankey, and Paul Hoyningen-Huene, 41–46. Dordrecht: Springer.

Hoyningen-Huene, Paul, and Eric Oberheim. 2009. "Reference, Ontological Replacement and Neo-Kantianism: A Reply to Sankey." *Studies in History and Philosophy of Science* 40:203–9.

Kuhn, Thomas S. 1970. *The Structure of Scientific Revolutions*. 2nd ed. Chicago: University of Chicago Press.

———. 1991. "The Road since Structure." In *PSA 1990: Proceedings of the 1990 Biennial Meeting of the Philosophy of Science Association*, vol. 2., ed. Arthur Fine, Mickey Forbes, and Linda Wessels, 3–13. East Lansing, MI: Philosophy of Science Association.

McShea, Daniel W. 1991. "Complexity and Evolution: What Everybody Knows." *Biology and Philosophy* 6:303–24.

Renzi, Barbara Gabriella. 2009. "Kuhn's Evolutionary Epistemology and Its Being Undermined by Inadequate Biological Concepts." *Philosophy of Science* 76:143–59.

Rosenberg, Alex, and Daniel W. McShea. 2008. *Philosophy of Biology: A Contemporary Introduction*. New York: Routledge.