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A Role for Taxonomic Incommensurability in Evolutionary Philosophy of Science

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In a review of my chapter (Marcum 2018), Amanda Bryant (2018) charges me with failing to discuss the explanatory role taxonomic incommensurability (TI) plays in my revision of Kuhn's evolutionary philosophy of science. To quote Bryant at length,

> One of Marcum's central aims is to show that incommensurability plays a key explanatory role in a refined version of Kuhn's evolutionary image of science. The role of incommensurability on this view is to account for scientific speciation. However, Marcum shows only that we can characterize scientific speciation in terms of incommensurability, without clearly establishing the explanatory payoff of so doing. He does not succeed in showing that incommensurability has a particularly enriching explanatory role, much less that incommensurability is "critical for conceptual evolution within the sciences" or "an essential component of…the growth of science" (168).

Bryant is right. I failed to discuss the explanatory role of TI for the three historical case studies, as listed in Table 8.1, in section 5, "Revising Kuhn's Evolutionary Image of Science and Incommensurability," of my chapter. Obviously, my aim in this response, then, is to amend that failure by discussing TI's role in the case studies and by revising the chapter's Table to include TI.

Before discussing the role of TI in the historical case studies, I first develop the notion of TI in terms of Kuhn's revision of the original incommensurability thesis. Kuhn (1983) responded to critics of the original thesis in a symposium paper delivered at the 1982 biannual meeting of the Philosophy of Science Association.

In the paper, Kuhn admitted that his primary intention for incommensurability was more "modest" than with what critics had charged him. Rather than radical or universal changes in terms and concepts—what is often called "global" incommensurability (Hoyningen-Huene 2005, Marcum 2015, Simmons 1994)—Kuhn claimed that only a handful of terms and concepts are incommensurable after a paradigm shift. He called this thesis "local" incommensurability.

More Common Than Incommensurable

Kuhn's revision of the original incommensurability thesis has important implications for the TI thesis. To that end, I propose three types of TI. The first is comparable to Kuhn's local incommensurability in which only a small number of terms and concepts are incommensurable, between the lexicons of two scientific specialties. The second is akin to global incommensurability in which two lexicons are radically and universally incommensurable with one another—sharing only a few commensurable terms and concepts.

An example of this type of incommensurability is the construction of a drastically new lexicon accompanying the evolution of a specialty. Both local and global TI represent, then, two poles along a continuum. For the type of TI falling along this continuum, I propose the notion of regional TI—in keeping with the geographical metaphor.

Unfortunately, sharper delineation among the three types of TI in terms of the quantity and quality of incommensurable and commensurable terms and concepts composing taxonomically incommensurable lexicons cannot be made currently, other than local TI comprises one end of the continuum while global TI the other end, with regional TI occupying an intermediate position between them. Notwithstanding this imprecise delineation, the three types of TI are apt for explaining the evolution of the microbiological specialties of bacteriology, virology, and retrovirology, especially with respect to their tempos and modes.

Revised Table. Types of tempo, mode, and taxonomic incommensurability for the evolution of microbiological specialties of bacteriology, virology, and retrovirology (see text for details).

Scientific Specialty	**Tempo**	**Mode**	**Taxonomic Incommensurability**
Bacteriology	Bradytelic	Phyletic	Global
Virology	Tachytelic	Quantal	Regional
Retrovirology	Horotelic	Speciation	Local

Examples Bacterial and Viral

As depicted in the Revised Table, the evolution of bacteriology, with its bradytelic tempo and phyletic mode, is best accounted for through global TI. A large number of novel incommensurable terms and concepts appeared with the evolution of bacteriology and the germ theory of disease, and global TI afforded the bacteriology lexicon the conceptual space to evolve fully and independently by isolating that lexicon from both botany and zoology lexicons, as well as from other specialty lexicons in microbiology.

For example, in terms of microbiology as a specialty separate from botany and zoology, bacteria are prokaryotes compared to other microorganisms such as algae, fungi, and protozoa, which are eukaryotes. Eukaryotes have a nucleus surrounded by a plasma membrane that separates the chromosomes from the cytoplasm, while prokaryotes do not. Rather, prokaryotes like bacteria have a single circular chromosome located in the nucleoid region of the cell.

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However, the bacteriology lexicon does share a few commensurable terms and concepts with the lexicons of other microbiologic specialties and with the cell biology lexicons of botany and zoology. For example, both prokaryotic and eukaryotic cells contain a plasma membrane that separates the cell's interior from the external environment. Examples of many other incommensurable (and of a few commensurable) terms and concepts make up the lexicons of these specialties but suffice these examples to provide how global TI provided the bacteriology lexicon a cognitive environment so that it could evolve as a distinct specialty.

Also, as depicted in the Revised Table, the evolution of virology, with its tachytelic tempo and quantal mode, is best accounted for through regional TI. A relatively smaller number of new incommensurable terms and concepts appeared with the evolution of virology compared to the evolution of bacteriology, and regional TI afforded the virology lexicon the conceptual space to evolve freely and self-sufficiently by isolating that lexicon from the bacteriology lexicon, as well as from other biology lexicons.

For example, the genome of the virus is surrounded by a capsid or protein shell, which distinguishes it from both prokaryotes and eukaryotes—neither of which have such a structure. Moreover, viruses do not have a constitutive plasma membrane, although some viruses acquire a plasma membrane from the host cell when exiting it during lysis. However, the function of the viral plasma membrane is different from that for both prokaryotes and eukaryotes.

Interestingly, the term plasma membrane for the virology lexicon is both commensurable and incommensurable, when compared to other biology lexicons. The viral plasma membrane is commensurable in that it is comparable in structure to the plasma membrane of prokaryotes and eukaryotes but it is incommensurable in that it functions differently. Finally, some viral genomes are composed of DNA similar to prokaryotic and eukaryotic genomes while others are composed of RNA; and, it is this RNA genome that led to the evolution of the retrovirology specialty.

And As Seen in the Retrovirological

As depicted lastly in the Revised Table, the evolution of retrovirology, with its horotelic tempo and speciation mode, is best accounted for through local TI. An even smaller number of novel incommensurable terms and concepts accompanied the evolution of retrovirology as compared to the number of novel incommensurable terms and concepts involved in the evolution of the virology lexicon vis-à-vis the bacteriology lexicon.

And, as true for the role of TI in the evolution of bacteriology and virology, local TI afforded the retrovirology lexicon the conceptual space to evolve rather autonomously by isolating that lexicon from the virology and bacteriology lexicons. For example, retroviruses, as noted previously, contain only an RNA genome but the replication of the retrovirus and its genome does not involve replication of the RNA genome from the RNA directly, as for other RNA viruses.

Rather, retrovirus replication involves the formation of a DNA provirus through the enzyme reverse transcriptase. The DNA provirus is subsequently incorporated into the host's genome, where it remains dormant until replication of the retrovirus is triggered.

The incommensurability associated with retrovirology evolution is local since only a few incommensurable terms and concepts separate the virology and retrovirology lexicons. But that incommensurability was critical for the evolution of the retrovirology specialty (although given how few incommensurable terms and concepts exist between the virology and retrovirology lexicons, a case could be made for retrovirology representing a subspecialty of virology).

Where the Payoff Lies

In her review, Bryant makes a distinction, as quoted above, between characterizing the evolution of the microbiological specialties via TI and explaining their evolution via TI. In terms of the first distinction, TI is the product of the evolution of a specialty and its lexicon. In other words, when reconstructing historically the evolution of a specialty, the evolutionary outcome is a new specialty and its lexicon—which is incommensurable locally, regionally, or globally with respect to other specialty lexicons.

For example, the retrovirology lexicon—when compared to the virology lexicon—has few incommensurable terms, such as DNA provirus and reverse transcriptase. The second distinction involves the process or mechanism by which the evolution of the specialty's lexicon takes place vis-à-vis TI. In other words, TI plays a critical role in the evolutionary process of a specialty and its lexicon.

Keeping with the retrovirology example, the experimental result that actinomysin D inhibits Rous sarcoma virus was an important anomaly with respect to the virology lexicon, which could only explain the replication of RNA viruses in terms of the Central Dogma's flow of genetic information. TI, then, represents the mechanism, i.e. by providing the conceptual space, for the evolution of a new specialty with respect to incommensurable terms and concepts.

In conclusion, the "explanatory payoff" for TI with respect to the revised Kuhnian evolutionary philosophy of science is that such incommensurability provides isolation for a scientific specialty and its lexicon so that it can evolve from a parental stock. For, without the conceptual isolation to develop its lexicon, a specialty cannot evolve.

Just as biological species like Darwin's Galápagos finches, for instance, required physical isolation from one another to evolve (Lack 1983), so the evolving microbiological specialties also required conceptual isolation from one another and from other biology specialties and their lexicons. TI accounts for or explains the evolution of science and its specialties in terms of providing the necessary conceptual opportunity for the specialties to emerge and then to evolve.

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Moreover, it is of interest to note that an apparent relationship exists between the various tempos and modes and the different types of TI. For example, the retrovirology case study suggests that local TI is commonly associated with a horotelic tempo and speciation mode—which to some extent makes sense intuitively. In other words, speciation requires far fewer lexical changes than phylogeny, which requires many more lexical changes or an almost completely new lexicon—as the evolution of bacteriology illustrates.

The proposed evolutionary philosophy of science, then, accounts for the emergence of bacteriology in terms of a specific tempo and mode, as well as a particular type of TI; and, it thereby provides a rich explanation for its emergence. Furthermore, the quantity and quality of taxonomically incommensurable terms and concepts involved in the evolution of the microbiology specialties suggest the following relative frequency for the different types of TI: local TI > regional RI > global TI.

The Potential of Evolutionary Paradigms

Finally, I proposed in my chapter that Kuhn's revised evolutionary philosophy of science is a good candidate for a general philosophy of science, even in light of philosophy of science's current pluralistic or perspectival stance. Interestingly, regardless of the increasing specialization within the natural sciences, these sciences are moving towards integration in order to tackle complex natural phenomena. For example, cancer is simply too complex a disease to succumb to a single specialty (Williams 2015).

The revised Kuhnian evolutionary philosophy of science helps to appreciate and account for the drive and need for integration of different scientific specialties to investigate complex natural phenomena, such as cancer. Specifically, one of the important reasons for the integration is that no single scientist can master the necessary lexicons, whether biochemistry, bioinformatics, cell biology, genomic biology, immunology, molecular biology, physiology, etc., needed to investigate and eventually to cure the disease. A scientist might be bilingual or even trilingual with respect to specialties but certainly not multilingual.

The conceptual and methodological approach, which integrates these various specialties, stands a better chance in discovering the pathological mechanisms involved in carcinogenesis and thereby in developing effective therapies. Integrated science, then, requires a systems or network approach since no one scientists can master the various specialties needed to investigate a complex natural phenomenon.

In the end, TI helps to make sense of why integrated science is important for the future evolution of science and of how an evolutionary philosophy of science can function as a general philosophy of science.

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