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BOOK REVIEW

The role of metaphor in shaping scientific inquiry

Andrew Reynolds: The third lens: Metaphor and the creation of modern cell biology. Chicago: University of Chicago Press, 2018, 272 pp, $30.00 PB

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The field of cell biology has been shaped by metaphors throughout its history, beginning with the metaphor of the cell as a container first used by Hooke in 1665. Metaphors are the "third lens" in the title of the book. The lenses alluded to are the lens of the metaphors used to study cells in addition to the two lenses of a compound microscope. Reynolds argues that metaphors have driven research programs, affecting idea generation, the development of research questions, protocol creation, and the interpretation of results. The book is a fun and engaging read on the history and use of metaphors in cell biology and as a case study of the role of metaphors and models in science more generally.

The Third Lens has six chapters. In Chapter 1, Reynolds examines the role metaphor played in the early development of cell theory and the controversy surrounding the basic unit of life. Reynolds highlights ways in which metaphors both promoted and hindered early research progress in cell biology. Cells were initially viewed as static building blocks of multicellular organisms. While this facilitated the identification of cell types across taxa, it hindered research progress in fields such as physiology and developmental biology.

In Chapter 2, Reynolds examines the importance of metaphor in shaping our understanding of the biochemical activities of the cell. He focuses on the metaphors of cells as factories, laboratories, and machines, which arose from the technological innovations of the nineteenth and twentieth centuries. Under this overarching metaphor, the components of cells are analogous to the parts of a factory. The perspective of the cell as a chemical factory and as a machine arose during a period of

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substantial economic development in Europe and the USA and was shaped by the societal experiences of scientists.

In Chapter 3, Reynolds focuses on the ways in which metaphors of the cell as a social entity have shaped cell and developmental biology. When viewed as social entities, cells were seen as capable of communicating with one another and influencing each other's behavior, similar to how humans in a society communicate and interact. By seeing multicellular development as being shaped by the social interactions among interacting cells, researchers were able to identify that multicellular organisms have emergent properties. Unfortunately, Reynolds overlooks the broader evolutionary context of social biology in which this has occurred. We are thinking here of the work of W. D. Hamilton, E. O. Wilson, M. Eigen and others in the 1960s and 1970s that applied social thinking to different levels in the hierarchy of life from molecules to cells to organisms. Surprisingly, Reynolds concludes the chapter by stating that the metaphor of cell sociology has not been essential to discovering or explaining important biological facts. He overlooks work on major evolutionary transitions which has been based on units of selection as social agents and which seeks to explain the evolution of the hierarchy of life, including the evolution of different kinds of cells, protocells, archaeal, bacterial, eukaryotic and cells in multicellular organisms. The lack of acknowledgement of the diversity of cell types and the use of metaphors in explaining them in an evolutionary framework is a missed opportunity in the book.

In Chapter 4, Reynolds focuses on how metaphors have shaped our understanding of cell signaling. For instance, the concept of signaling pathways, a term that originated in electrical engineering before becoming prevalent in biology, was initially used to understand intracellular interactions.

In Chapter 5, Reynolds discusses whether metaphors play a role in the development and evaluation of scientific explanations. He argues that the use of metaphors can result in deeper knowledge and understanding. Metaphors can facilitate the development of new hypotheses as they illuminate a new perspective, allowing for lines of inquiry to be formulated in ways that would not be feasible with the use of literal language. Reynolds also argues that metaphors can be explanatory and guide the development of research programs. Metaphors do more than just provide a new perspective; they shape the research questions that researchers ask and the explanations they propose.

Chapter 6 focuses on the purpose and nature of science and the relationship between metaphors and scientific realism. Metaphors do not give us an objective, literally true account of the world. If the goal of science is to give us a literally true account of the world, then the use of metaphors is inconsistent with that goal. Instead, metaphors act as conceptual tools that give us insight into the world. This important heuristic role is consistent with the use of models generally in science.

Reynolds concludes by encouraging scientists to be aware of the role metaphors play in their fields. He hopes that researchers will be inspired to move the conversation about metaphor forward in their respective scientific fields. We were so inspired in our field of research, the study of evolutionary transitions in individuality (ETIs). Cells are levels in the hierarchy of life, protocells, bacterial and archaeal cells, eukaryotic cells, cells in multicellular organisms. Groups of cooperating genes

evolved into genomes in protocells, groups of bacterial and archaeal cells evolved into eukaryotic cells, groups of cells evolved into multicellular organisms, and groups of multicellular organisms evolved into eusocial societies. During each transition, the unit of selection, organization, and adaptation, that is, the evolutionary individual, changes. During transitions between these different kinds of individuals, groups of individuals become highly integrated and evolve into a new kind of individual, that is, a new level in the hierarchy of life. These transitions are referred to as ETIs, and the theory of ETIs seeks to explain the evolution of this hierarchical organization of life (see, for example, Michod 1999; West et al. 2015). While Reynolds primarily discusses the history of research on the cells that make up eukaryotic multicellular organisms, the ETI framework explains the evolution of other types of cells that make up the hierarchy of life.

The study of ETIs is underpinned by the metaphor of units of selection as social entities—a metaphor Reynolds discusses in Chapter 3. The metaphor of evolutionary individuals as social agents is essential to the understanding that evolutionary transitions occur when groups of socially interacting individuals evolve into new kinds of individuals. These interactions take the form of cycles of cooperation, conflict, and conflict mediation (see, for example, Michod and Roze 2001)—concepts that would not have been readily apparent without viewing individuals as social agents.

The use of a theoretical framework that imports concepts from the field of behavior and views evolutionary individuals as social entities has allowed researchers to explain the remarkable evolutionary transitions that have occurred during the history of life on earth. The study of interactions is central to explaining the evolution of complex life through a series of ETIs. Therefore, key ETI concepts can potentially serve as useful metaphors for understanding other complex systems with interacting components. In line with this, *Philosophical Transactions of the Royal Society B* recently published a special issue that uses ETIs as a framework through which to examine human social and cultural evolution (Carmel et al. 2023). This special issue was motivated by the need to understand the complex nature of human societies, technology, and culture.

As part of this special theme issue as well as elsewhere (see Davison et al. 2021), we have used our understanding of biological ETIs to examine whether a comparable process may have occurred during the evolution of human culture. We began by applying criteria developed to identify and characterize evolutionary individuals in biology to human and chimpanzee culture. We found that groups of chimpanzee cultural traditions satisfied almost none of the individuality criteria while integrated sets of hominin cultural traditions satisfied many of the criteria, with the number of criteria satisfied likely increasing over evolutionary time. The increasing integration of groups of hominin cultural traditions is consistent with the occurrence of an evolutionary tradition in the cultural realm (Davison et al. 2021). Moreover, when we examined how the steps of a biological ETI could have occurred during the evolution of culture, we found that it was not clear if cycles of selection dynamics involving cooperation and conflict mentioned above have occurred in cultural evolution. While cooperation, conflict, and conflict mediation certainly exist among human cultural traditions, integrated groups of traditions may not proceed through

these stages (Davison and Michod 2023). Although there are important similarities between transitions in the biological and cultural realms, the differences between these transitions show the possible limits of viewing one field through the lens of another field. Similarly, *The Third Lens* shows that metaphors can shape the direction of scientific inquiry and the application and potential limitations of metaphors must be critically examined and acknowledged as science proceeds.

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