SPECIAL ISSUE

Introduction to Symposium on Fossil-Driven Science

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The following papers reconstruct and extend a session hosted by the Society for the Philosophy of Scientific Practice at the 2022 meeting of the Philosophy of Science Association. The goal of the session was to look beyond questions about incompleteness in the fossil record and consider other ways fossil-driven science might enhance our understanding of scientific practice. While this session focused on a specific conversation in historical science, it models an ongoing and significant turn in the discipline. The centering of incompleteness is a paradigmatic example of how philosophical scaffolding from the early twentieth century continues to influence contemporary discussions. If the goal is to construct an algorithmic model of scientific inference that takes us from "neutral data" to incontrovertible theory, then the sparseness of fossils preserved, the biases of nature regarding what is preserved, and the social biases concerning what fossils are excavated and studied present significant obstacles to "good science." In a similar vein, if one wants to show why the ideal of purely-objective-and-value-free scientific inference is inconsistent with actual practice, the incompleteness of the fossil record is a perfect exemplar of how many complicating (and social) factors play a role in the construction of scientific knowledge.

But what if we were to eschew this scaffolding and look with fresh eyes at the multifaceted ways scientists engage with fossils? This is precisely the task taken on by the authors here. Douglas Erwin, Senior Research Biologist and Curator of Paleozoic Invertebrates at the Smithsonian National Museum of Natural History, offers a paleontologist's perspective on shifting attitudes towards incompleteness, and details how current advances in technology and new questions about the history of Earth are changing the way scientists construct knowledge from fossils. Caitlin Wylie, a scholar of science and technology studies at the University of Virginia, uses a close analysis of the fossil preparation process to argue that scientists' research schedules (e.g., grant deadlines and career stage) – what Wylie calls "scientist time" – reflect their professional values and crucially shape the way they select, interpret, and disseminate data. Aja Watkins, philosopher of science at the University of Wisconsin-Madison, argues that the complex (and temporal) relationship between natural fossil production and human interest in fossil evidence raises critical questions for current theories of data. Adrian Currie, a philosopher of science in Egenis, the Centre for the Study of the Life Sciences at the University of Exeter, draws on

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David Hull's notion of "central subjects" and a case-study of recent palaeobiological reconstructions of *Spinosaurus aegypticus* to sketch how fossils provide fertile soil for biological possibility spaces.

Each paper models how close attention to the actual contours of scientific practice delivers new insights about the multifaceted process of scientific knowledge construction; moreover, while all four papers focus on the use of fossils, the diversity of the topics addressed in the symposium show the many different epistemic functions a single fossil might play depending on the context, training, and interests of the researcher who holds it. When taken as a whole, the symposium displays a break from traditional ways of framing academic dialogues. Rather than address a shared question (e.g. "should we be realists about specimens in science?") or display a shared methodology (e.g. "Humean approaches to quantum mechanics"), this conversation is woven together by a collective focus on a particular type of biological specimen. Uniting the papers in this way makes room for diversity in both the scientific methodologies considered and the disciplinary lenses through which that reflection is shaped. Centering this inquiry around a material object is in many ways a microcosm of geoscience itself, in which different perspectives are not unified into a single view but instead woven together into complex models or preserved as interlocutors in ongoing scientific dialogues.

However, despite this general scientific trend towards multidisciplinarity and integration, the survival of earlier disciplinary strategies may depend on their ability to adapt to shifting scientific priorities. This is precisely the problem taken up by Douglas Erwin in "Quo Vadis." Erwin partitions the last 200 years of paleontological research into three different stages that are demarcated by different disciplinary attitudes towards the fossil record. The first stage took incompleteness and bias in the fossil record to greatly limit the ability of what paleontologists might study. In the second stage, rather than viewing incompleteness as a worrisome constraint, paleontologists emphasized the reliability of the information that had been preserved and were at times overconfident about the possibilities of the discipline. In the third stage, a synthesis emerged: there is general agreement that the fossil record preserves a good deal of information, and that incompleteness may prove a significant factor when investigating certain research questions. As a result, contemporary paleontologists pursue a multiplicity of questions with hopeful expectation but also take seriously the importance of assessing the reliability of their datasets in relation to the questions they ask. Increasing diversification of paleontological research programs reflects growing scientific interest in the history of life, along with the advent of new scientific methods (i.e. phylogenetics, evo-devo and geochemistry) to approach these questions. Integrating these radically different approaches requires a reframing of paleontological research and education to prioritize one's specialization around questions and methods rather than a clade and time interval. Erwin ends by pondering whether there is a future for traditional paleontology, or if the discipline must evolve into a new approach to stay relevant to changing scientific interests.

Shifting the scale of analysis from fossil-driven disciplines to the work of individuals, Caitlin Wylie examines temporal constraints to illustrate how values shape knowledge-production in "Timing Science." Building on the work of Sabina Leonelli, who argues the function of data in scientific inference relies on interactions between temporal dimensions of collecting and managing a piece of data (data-time) and the natural process the data acts as evidence for (phenomena-time), Wylie introduces an additional contributor to the temporal properties of data: scientist-time. Data is processed and managed by scientists and other workers, whose temporal frameworks include factors such as career-stage and project timelines. These timelines derive from professional values of what it means to be a good researcher or technician, alongside practitioners' personal values and identities. Many choices about what data to collect and how to process

and disseminate it depends on the institutional (and individual) timelines scientists work within. Wylie develops her account of scientist-time through studies of fossil preparation and use, both historical and contemporary, revealing the ways in which scientist-time shapes research. Of particular note is Wylie's first-hand description of the work done by a fossil preparator reconstructing a horse's jaw which had been previously prepared and deteriorated. When faced with various problems in terms of how to reassemble the piece, the preparator is forced to make time-constrained judgment calls which may forever alter the evidentiary contributions the fossil makes to reflections on the history of life. Wylie's work exemplifies how careful attention to fossil-driven science can further develop models of scientific inference.

Aja Watkins takes a more abstract look at the preparation and journey of fossils in "When Are Fossils Data?" Both Sabina Leonelli's relational view of data (2019, 2020) and Alisa Bokulich and Wendy Parker's pragmatic-representational view (2021) focus on cases where an object acquires a particular epistemic function at or very close to the time when it is involved in a scientist-world interaction. This moment of overlap is significant for both views, serving as the point when an object begins what Leonelli calls a "data journey," the course by which it is transformed into a piece of evidence for a particular question (Leonelli 2020). However, as Watkins points out, fossils undergo natural processes that are interestingly analogous to human preparatory practices long before they are discovered; symmetries in these pre and post collection processes makes first-human-contact seem like an arbitrary "starting point" for a data journey. Moreover, we are often aware that fossils exist which would potentially serve as evidence for a question even though they have yet to be collected. In the case of fossils, then, there can be a rather large temporal gap between an object becoming potential evidence and participating in a human-world interaction. Watkins goes on to explore several ways one might respond to the title question of her paper in light of this ambiguity and clarifies how these moves might impact various data-related concepts.

In the final paper, Adrian Currie explores the possibility space surrounding fossil-driven science. In "Fossils, Modality, and Central Subjects in Palaeobiological Reconstruction," Currie surveys recent palaeobiological reconstructions of *Spinosaurus aegypticus* generated to determine whether *Spinosaurus* was a primarily aquatic animal or a terrestrial animal with aquatic adaptations. To evaluate the degree to which *Spinosaurus* engaged with aquatic environments, speculative reconstructions (both digital and robotic) of Spinosaurus have been developed and "tested" across sundry biological contexts. Currie argues that the scientific methods involved in the recent Spinosaurus debates cannot be accommodated by the traditional view on which fossils are used to test hypotheses about the past. Instead, he argues, fossils here serve as a foundation for the construction of biologically constrained possibility spaces which can be used to extract relevant modal information. However, given that the various biological profiles used in the Spinosaurus are speculative modal spaces generated from radically different approaches to the physical evidence, two worries emerge about their use: first, why think they are tracking something physically relevant and two, why think scientists using these radically different methods can engage in substantive debate rather than mere cross-talk? Currie draws on David Hull's notion of "central subjects" (1975) to account for how fossils both drive and unify the relevant science: *Spinosaurus* serves as the central subject around which these diverse narratives are built. Much like the papers in this symposium, these speculative modal spaces interact with each other and the world through their shared interest in a particular physical specimen: fossils.

While there is an increased acceptance both among scientists and philosophers of science that the scientific method admits of a diversity of views, there remains the question of how we integrate these views into communal scientific knowledge.[1] This conversation about fossils

1. See, for example, Longino (2019).

shows one path forward: integration happens through conversation. The trick, then, is to find ways to structure our conversations about science in a way that allows for different perspectives to develop autonomously but also remain conversant with one another. These papers show one approach to this task: structuring dialogues around material specimens.

Literature cited

Bokulich, A., and W. Parker. 2021. "Data Models, Representation, and Adequacy-for-Purpose." *European Journal for Philosophy of Science*, 11: 31. https://doi.org/10.1007/s13194-020-00345-2.

Leonelli, S. 2019. "What Distinguishes Data From Models?" *European Journal for Philosophy of Science*, 9 (2): 22. https://doi.org/10.1007/s13194-018-0246-0.

Leonelli, S. 2020. "Learning from Data Journeys." In *Data Journeys in the Sciences*, edited by S. Leonelli and N. Tempini, 1–24. Springer. https://doi.org/10.1007/978-3-030-37177-7_1.

Longino, Helen E. 2019. *Studying Human Behavior: How Scientists Investigate Aggression and Sexuality*. Chicago: University of Chicago Press.

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