

Review of Caitlin Donahue Wylie's *Preparing Dinosaurs: The Work Behind the Scenes*

Caitlin Donahue Wylie, *Preparing Dinosaurs: The Work Behind the Scenes*. Cambridge, MA: MIT Press (2021), 264 pp. \$75.00 (paperback)

Preparing Dinosaurs: The Work Behind the Scenes, by science and technology studies scholar Caitlin Donahue Wylie, presents the results of an ethnographic study of different communities of fossil preparators and their pivotal—though quite often unrecognized—role in vertebrate paleontology. After summarizing Wylie's main contributions, we discuss how fossil preparation may be of interest to philosophers of data, especially those interested in metadata practices.

After being recovered, fossils are not immediately available to researchers but rather have to undergo a long process that eventually turns them from natural objects into specimens that can be studied (3). Fossil preparators are some of the people in charge of this epistemologically crucial process (chapter 1). Fossils might need to be separated from background noise by removing the surrounding rock matrix, to be reassembled, or to be made mobile for use in subsequent research purposes: as a consequence of this multiplicity of goals, preparators show great methodological flexibility in their techniques and approaches, usually informed by aesthetic considerations, tacit priorities, and a tendency to innovation and creativity (26, 29, 49). According to Wylie, the autonomy of preparators to make methodological decisions concerning fossil preparation is a defining characteristic of preparators' communities. Preparators' autonomy, in turn, is made possible by their relatively invisible role; the work of preparators is seldom recorded or mentioned in scientific publications, which reduces the potential for paleontologists to exercise oversight over preparators' actions.

Despite the lack of standardized procedures, Wylie argues that preparators' communities are built around shared values (e.g., patience, attention to detail, visual judgments), and common methodological concerns about fossil specimen preservation (chapter 2). Differences in abilities and skills also produce a hierarchical structure within preparator communities, differentiating technicians from volunteers and resulting in different tasks assigned to each group (94). Wylie's analysis of communities is also informed by her investigation of the role that technologies play in the process of fossil preparation. In particular, the recent introduction of computed tomography scans to paleontological research, and the consequent possibility to avoid manually intervening on the fossil and thus potentially damaging it, has initiated a reflection by preparators on the value of different preparation techniques. Wylie describes the debate surrounding benefits and limitations of new technologies and how they coexist along with more traditional approaches to fossil preparation, insofar as they serve different epistemic purposes (chapter 3).

In the fourth chapter, Wylie discusses to what extent preparators and scientists need to iteratively negotiate their priorities to converge on a "researchable fossil" (138). The interaction between researchers and preparators revolves around

a trade-off between maximizing research output and minimizing preparation time (142). This iterative negotiation is made possible only by a mutual understanding of priorities and values that also requires a common language to communicate and transform knowledge. In her analysis, Wylie highlights the mutual interdependence of researchers and preparators, under the common goal of advancing scientific knowledge, without which the two groups would struggle to align their opinions and values.

The final chapter of *Preparing Dinosaurs* is devoted to public science and how museums portray scientific practice by frequently installing windows into preparation laboratories in their exhibitions. Wylie carefully elucidates the purpose of showing the public preparators at work, which invites museum visitors to reconsider the standard conception of science as a static collection of facts in favor of a more dynamic, contextual activity. Wylie also points out a possible synergy between this educational goal and museums' directive to entertain the public.

Through this detailed ethnographic exploration of what happens before a fossil reaches a museum's exhibition or is used in scientific research, Wylie provides a convincing theoretical framework according to which knowledge is *prepared* via an iterative process in which different specialized research workers contribute to knowledge products. The metaphor of "preparation," which Wylie applies to specimens, communities, technologies, and public conceptions of science, is supposed to provide a middle ground between traditional realist and social constructivist conceptions of science (for further discussion, see Currie 2023). For philosophers of science, "preparing knowledge" can be a useful heuristic tool that emphasizes stages and protagonists of scientific research usually black-boxed by accounts of science that look only at the collection of evidence and the production of results, to the neglect of the complex processes that happen in between. For example, Wylie's investigation highlights the various elements that enter the process of turning "natural objects" into "researchable fossils," ranging from more individual judgments about the aesthetic value of a specimen to communal values negotiated through the iterative processes of preparing communities. As a result, Wylie's ethnographic approach (above and beyond existing historical studies of paleontology; e.g., Rieppel 2019) has the potential to be extremely valuable for philosophers of science, especially for those concerned with the nature and use of data and evidence.

One of the most philosophically interesting issues illuminated by Wylie's account of "preparing knowledge" has to do with how data and metadata are collected and managed in a paleontological context. Several philosophers of science are in agreement with Wylie that we should think of prepared fossils as data or data models (e.g., Bokulich 2021; Leonelli 2018). Preparing fossils involves separating signal from noise, for example, just as many other data processing practices do. Additionally, as Wylie (2019) has also argued, prepared fossils are underdetermined by "raw" specimens; preparators' creative decisions shape prepared fossils for later use as evidence by paleontologists. In preparing fossils, preparators have to make some predictions about the scope of the future evidential use of the specimens, such as what material will and won't be informative.

Philosophers and scientists alike are increasingly in agreement that one of the necessary conditions for use of data as evidence is availability of ample and usable metadata. For example, Nora Boyd (2018) discusses the need for evidence to

be “enriched” with metadata—both what she calls “provenance metadata,” about the origins of the data, and “workflow metadata,” concerning how the data have been processed so far. Sabina Leonelli (2018) has also stressed the importance of metadata for scientists’ ability to interpret data or reuse them in additional research contexts. One might, then, reasonably assume that the same holds in the paleontological context: that metadata about how fossils are prepared would be a necessary ingredient for their future use and interpretation.

However, one of the most striking features of Wylie’s account of fossil preparation and the fossil preparator community is just how seldom workflow metadata about fossil preparation are collected. By contrast, provenance metadata, concerning the fossil’s location and position before extraction, are often collected and used by paleontologists. For example, Wylie writes, “by choosing how to work with fossils, preparators make momentous, though rarely documented, decisions about the physical and epistemic characteristics of the evidence they prepare” (102). In chapter 4, Wylie also discusses the fact that the work of preparators is rarely acknowledged or discussed in scientific publications. Of course, across all of paleontology, there are bound to be exceptions—cases in which preparation metadata *are* systematically collected—and it would be interesting in future work to see if there are any patterns that delineate the research communities that adopt or do not adopt this practice. For example, Wylie mentions how paleoanthropologists and invertebrate paleontologists divide labor differently from vertebrate paleontologists, which consequently affects data management, publication practices, and more (12).

On the basis of existing philosophical accounts concerning the importance of metadata for enabling data to be used as evidence, we might, then, assume that the lack of workflow metadata in the context of fossil preparation would be a flaw in paleontological practice. On one hand, Wylie (2019, 16) attributes this absence of workflow metadata to a general tendency of obscuring the work of making fossils researchable, a tendency that “limits specimens’ potential uses and interpretations as scientific evidence by omitting information about how they were processed.” On the other hand, she argues that the lack of documentation of fossil preparators’ work goes hand in hand with a lack of oversight of their work by the paleontologists themselves, which, in turn, preserves the preparators’ autonomy. For instance, she writes,

a lack of recognition can protect practitioners’ autonomous decision making, while, by contrast, imposing documentation of previously unwritten work can cause the insulting “eradication of discretion from skilled workers.” So if scientists begin to coauthor with preparators or record preparators’ methods in print, it’s likely that the scientists would pay more attention to preparators’ training and methodological decisions, and try to align them with scientists’ own relatively standardized backgrounds and techniques. This would limit or even deny preparators’ cherished creative problem solving and control over their practices. (208, citing Star and Strauss 1999)

From a philosophical perspective, this conflict is surprising and indicates that there will be trade-offs between the potential epistemic benefits of metadata and the likely costs of collecting or reporting such metadata to the workers involved. Philosophers of the historical sciences may be able to provide advice on how to negotiate this

trade-off, for instance, by welcoming Wylie's (2019) suggestion as to how preparators can record their work (in specimen records but not in publications) or by helping to describe the range of ways in which a lack of workflow metadata about fossil preparation techniques constrains or limits the evidential value of fossil data.

Furthermore, the emphasis Wylie places on the preparators' autonomy—perhaps over and above the possible epistemic gains of imposing metadata reporting requirements on preparators—calls attention to one of the broader themes of *Preparing Dinosaurs* overall, namely, that science is not only conducted by and for scientists but incorporates the labor and expertise of a wide range of workers with different backgrounds, incentives, skills, and prestige. Wylie's account of knowledge preparation thus serves as a needed reminder to practice-oriented philosophers of science that oftentimes the scientific practices that do *not* make it into scientific publications, or cannot even be learned about by talking to trained scientists, can have serious implications for the structure and scope of scientific research.

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Review of Slobodan Perović's *From Data to Quanta – Niels Bohr's Vision of Physics*

Slobodan Perović, *From Data to Quanta – Niels Bohr's Vision of Physics*. Chicago, IL: The University of Chicago Press (2021), 280 pp., \$45 (cloth).

Of late, there has emerged a promising strand in the historical and philosophical literature on Bohr that focuses on the central importance assigned in his view to the details of the experimental context under which observations of the systems