

## Making Animal Materials in Time

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### ABSTRACT

This special issue, "Making Animal Materials in Time," delves into the history of animal materials used in craft and scientific endeavors since the eighteenth century. We regard animal materials as dynamic elements with particular properties granted context-specific and culturally fluid meanings by those who work with them—often to the point of dissolving their original animal materiality. Focusing on this multi-dynamic at the intersection of history of science and the anthropology of techniques permits a reformulation of the concept of affordance, as material affordances, to create the theoretical capacity for a discussion of the diverse processes of rendering animal bodies into new substances, materials, and things. Six case studies illustrate how human historical actors distinguished animal materials as they observed, envisioned, extracted, processed, and changed animal bodies and tissues into new elements. Collectively, these papers present a strategy for examining connections between the spatial and temporal qualities of animal materials situated in human-scale material practices. The animal materials featured in this special issue serve as boundary objects across practical settings, contexts, regions, and cultural world settings that instrumentally link the history of science to anthropologies of craft knowledges.

KEY WORDS: animal materials, animal materialities, artisanal craft processes, rendering, material affordances

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Throughout history, humans have used animal body parts and substances for practical, creative, scientific, and commercial ends in ways that render them unrecognizable when compared to their original animal state. This special issue reflects an endeavor to notice and engage with animal materials as elements

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with properties—agency-based, changeable, relational, temporal—in order to fully consider the practical and ethical dimensions of both animal materials and their makers at different scales and in different historical moments since the eighteenth century. A process of learning across two fields, history of science and the anthropology of techniques, facilitated by the Proteins and Fibers working group at the Max Planck Institute for the History of Science, allowed us to ask one another: *what are animal materials?* This led to a series of related questions that expanded over several years of interdisciplinary scholarly exchanges involving materials scientists, bioarcheologists, museum curators, and conservators: How do human historical actors define the various animal materials they work with? How have humans made and transformed animal materials, or witnessed their composition, decomposition, and repurposing relative to the animal body? To what extent do animal materials retain their animal nature even as their properties change? And, finally, when and how do animal materials become more-than-animal? Turning from the whole organism to animal materials, this special issue outlines a framework for methodological and conceptual discussions of animal materiality specific to places, processes, and time. Drawing on insights from material culture studies and design studies, and reflecting on how the social sciences have worked with the concept of affordance, we have formulated a working concept of “material affordances” to address these questions.

In the 1960s and 1970s, American psychologist James J. Gibson coined the term “affordance” to conceptualize what an environment “offers the animal or what it *provides* or *furnishes*.” He explained how animals’ (including humans’) cognition of their surrounding environment informed the contingencies that enabled further potential action.<sup>1</sup> Psychologist Eleanor Gibson furthered the concept in early childhood development research, examining children’s active perceptual engagement with the environment prior to language development.<sup>2</sup> Scholars in design, engineering, anthropology, and science and technology studies (STS) have since adapted Gibson’s eco-psychological concept of affordance. By the late 1980s, the implications of affordance circulated among design scholars concerned with consumer goods. Cognitive scientist Donald

1. James J. Gibson, *The Senses Considered as Perceptual Systems* (Boston: Houghton Mifflin, 1966); James J. Gibson, *The Ecological Approach to Visual Perception* (Boston: Houghton Mifflin, 1979), 127.

2. Eleanor J. Gibson, “The Concept of Affordances in Perceptual Development: The Resurgence of Functionalism,” in *The Concept of Development: The Minnesota Symposia on Child Psychology*, vol. 15, ed. Willard A. Collins (Hillsdale, NJ: Erlbaum, 1982), 55–81.

Norman conceptualized it as the clues in an object that determine its possible usages. His definition emphasized the interrelations between the designer, the artifact's properties, and the capabilities of users who interact with a specific design based on their needs.<sup>3</sup> Beginning in the 1990s, scholars in technology studies drew on affordance to emphasize technology's social embeddedness. For social anthropologist Bryan Pfaffenberger, technological affordances are a technology's constitutive possibilities and constraints; affordances are "inherently multiple" and determined by the technology's properties, the attributes of its specific environment, and social practices.<sup>4</sup> According to Pfaffenberger, affordances maintain social structures because technological artifacts and their affordances are politically constructed and have a political impact on their users. His stance on the power of affordances resonates with Madeleine Akrich and Bruno Latour's view that technological affordances have a regulating, normative effect that prescribes, proscribes, or permits human actors to do certain things.<sup>5</sup>

Analysis of affordances allowed researchers to venture beyond STS frameworks bound by relational and social shaping or construction of materials qua technology,<sup>6</sup> or what was called material semiotics, wherein materials are continually "enacted" through local practices, gain meaning, and come to matter, especially when ontological norms are challenged.<sup>7</sup> The discussion of affordances that developed across the social sciences emphasizes how the properties of environments and objects encourage or constrain the possible actions that arise as relations between human actors and material things change. During the 2000s, STS and human-computer interaction studies scholars examining changing digital technologies pointed to the need to

3. Donald Norman, *The Design of Everyday Things* (New York: Basic Books, 1988).

4. Bryan Pfaffenberger, "Social Anthropology of Technology," *Annual Review of Anthropology* 21 (1992): 491–516, on 503, quoted in Gale Parchoma, "The Contested Ontology of Affordances: Implications for Researching Technological Affordances for Collaborative Knowledge Production," *Computers in Human Behavior* 37 (2014): 360–68, on 363. See also Bryan Pfaffenberger, "Technological Dramas," *Science, Technology, and Human Values* 17, no. 3 (1992): 282–312.

5. Madeleine Akrich and Bruno Latour, "A Summary of a Convenient Vocabulary for the Semiotics of Human and Nonhuman Assemblies," in *Shaping Technology / Building Society: Studies in Sociotechnical Change*, ed. Wiebe E. Bijker and John Law (Cambridge, MA: MIT Press, 1992), 261.

6. Wiebe E. Bijker, Thomas P. Hughes, and Trevor J. Pinch, eds. *The Social Construction of Technological Systems* (Cambridge, MA: MIT Press, 1989).

7. John Law, "The Materials of STS," in *The Oxford Handbook of Material Cultural Studies*, ed. Dan Hicks and Mary Beaudry (Oxford: Oxford University Press, 2010), 171–86.

recognize how new affordances regularly arise as the technologies they are associated with are constructed or repurposed socially, historically, economically, and legally. In addition, after 2007, anthropologist Tim Ingold's interpretation of affordance theory expanded discussions into material culture.<sup>8</sup> Despite its success, critical analysis of affordance theory in technical design has pointed out that it can problematically invite a deterministic view of hard-wired constraints, or pose a misleading idea that all potential affordances could be weighed in advance of choice making.<sup>9</sup> To counter an unbridled use of affordance that threatened to make it amorphous over time, communication technology scholars have sought more nuanced working concepts that recognize how the material qualities of technologies have affective and emotional aspects that inform the imagination of their users.<sup>10</sup> Social psychologist Jenny L. Davis has especially encouraged technology studies scholars to update simplistic and misleading interpretations of inert objects as those that do or do not afford with more precise explanations of how human–technology relations work.<sup>11</sup> Indeed, as technologies embedded in society, animal materials may be loaded with aesthetic, economic, cosmological, social, and/or other intangible values and have politics in their design and usage.<sup>12</sup> They are just as capable as technologies such as Bakelite or paper of shaping and empowering

8. Shay David and Trevor Pinch, "Six Degrees of Reputation: The Uses and Abuses of On-Line Reputation Systems," in *Living in a Material World: Economic Sociology Meets Science and Technology Studies*, ed. Trevor Pinch and Richard Swedberg (Cambridge, MA: MIT Press, 2008), 341–73; Harold S. Jenkins, "Gibson's 'Affordances': Evolution of a Pivotal Concept," *Journal of Scientific Psychology* 12 (Dec 2008): 34–45; Tim Ingold, "Materials against Materiality," *Archaeological Dialogues* 14, no. 1 (Jun 2007): 1–16.

9. Janet Vertesi, "From Affordances to Accomplishments: Powerpoint and Excel at NASA," in *DigitalSTS: A Field Guide for Science & Technology Studies*, ed. Janet Vertesi and David Ribes (Princeton, NJ: Princeton University Press, 2019), 369–92.

10. Peter Nagy and Gina Neff, "Imagined Affordance: Reconstructing a Keyword for Communication Theory," *Social Media + Society* 1, no. 2 (Jul 2015): 1–9. <https://journals.sagepub.com/doi/pdf/10.1177/2056305115603385>

11. Jenny L. Davis, *How Artifacts Afford: The Power and Politics of Everyday Things* (Cambridge, MA: MIT Press, 2020), 6–13, 40–68, 89–91.

12. See, for example, Thomas D. Finger, "Trading Spaces: Transferring Energy and Organizing Power in the Nineteenth-Century Atlantic Grain Trade," in *New Natures: Joining Environmental History with Science and Technology Studies*, ed. Dolly Jørgensen, Sara Pritchard, and Finn Arne Jørgensen (Pittsburgh: University of Pittsburgh Press, 2013), 151–63; Langdon Winner, "Do Artifacts Have Politics?," *Daedalus* 109, no. 1 (1980): 121–36; Bryan Pfaffenberger, "Technological Dramas," *Science, Technology and Human Values* 17, no. 3 (1992): 282–312; Christine Holmberg, Stuart Blume, and Paul Greenough, eds., *The Politics of Vaccination: A Global History* (Manchester: Manchester University Press, 2017).

communities of scientific and craft practices or societies at large.<sup>13</sup> Their affordances may not be perceived as widely or as readily, but they are an integral part of the continuous process of noticing various properties while making animal materials. Affordance theory has long been ripe for retooling. Updating it in the context of animal materials, through case studies that encourage looking beyond the understanding that materials can have agency and interrelate with humans to yield material culture, may also throw a net wider than a discussion of the mechanisms or consequences of technologies.

The various human or animal actions afforded by perceptual ecologies, designs, and technologies echo the evolutionary adaptive responses of organisms to environmental changes or other contingencies that biologists have examined. German biologist and semiotician Jakob von Uexküll, for instance, outlined how an animal can determine a set of functions in its surroundings, demarcating a specifically perceived and thus experienced environment that he called the *Umwelt*.<sup>14</sup> Von Uexküll's emphasis on function mirrors James Gibson's stress on affordances as actions humans make in relation to perception triggered by cues in their environment. While it is not entirely clear if Gibson drew upon von Uexküll directly, he did draw numerous insights from studies on animal behavior and regarded the ecological niche as a set of affordances. Gibson stressed that affordances are not subjectively known properties as experienced by an individual (like pleasure or pain), but known in reference to other subjective standpoints. He pointed out the neutrality required to perceive how, for example, an elongated elastic object (also known by terms such as fiber, thread, or rope) can afford knitting, binding, knotting, and weaving. In focusing on how things are perceived, he deliberately bypassed the obligation to label or classify any given object and its qualities, honing in on ascertaining their various affordances instead.<sup>15</sup> The recognition of multiple

13. Boris Jardine, "State of the Field: Paper Tools," *Studies in the History and Philosophy of Science* 64 (2017): 53–63; Wiebe E. Bijker, "The Social Construction of Bakelite: Toward a Theory of Invention," in *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology* (Cambridge, MA: MIT Press, 1987), 159–87.

14. Jakob von Uexküll, *A Foray into the Worlds of Animals and Humans: With a Theory of Meaning*, trans. Joseph D. O'Neill (Minneapolis: University of Minnesota Press, 2010), 124–26, originally published as *Streifzüge durch die Umwelten von Tieren und Menschen* (Berlin: Julius Springer, 1934); Jakob von Uexküll, "A Stroll through the Worlds of Animals and Men: A Picturebook of Invisible Worlds," in *Instinctive Behavior: The Development of a Modern Concept*, ed. Claire H. Schiller (New York: International University Press, 1957), 5–80.

15. Gibson, *The Ecological Approach to Visual Perception*, 134–37. See chapter 3 for a discussion of manipulation of objects.

affordances associated with an object in Gibson's approach depends greatly on the perceptions generated by the optical senses of multiple ecologically situated individuals. Expanding on this, we suggest that the embodied experiences of handling and dealing with animal materials potentially highlight how material affordances gain apperency. Rather than uphold distinctions of objective and subjective knowing, we reject boundaries of how things and properties are recognized, in order to broaden the discussion of what animal materials are, to what they are good for, especially as our intention is to understand *both* the recognition of their potential and the contexts and consequences of past choices surrounding the earlier manipulation of the animal body.

The history of science is littered with animal materials. Scholarly analyses of efforts to artificially produce materials like saltpeter, a byproduct of the decomposition of excreted animal waste, and efforts to fix unique dyes to plant fibers by masking them with animal oil, excrement, and blood to produce animal-like properties hint at how animal materials have inspired European experimentation in alchemical and artisanal settings since at least the 1600s.<sup>16</sup> A historical discussion of animal materials is practically impossible without acknowledging animal death or the consumption of animal flesh for nourishment and enjoyment.<sup>17</sup> Of course, many of the discussions about animal materials and affordance highlighted by this special issue can apply to plants. However, *how* animals die in vastly different ways than plants raises an ethic of knowledge that must be grappled with when contemplating how people have worked with animals—whether they are slippery swimmers, multi-legged critters, winged and feathered, or charismatic and warm-blooded—or whether they are entrails, bones, mucous membranes, shells, scales, tissues, or teeth. The history of determining the edibility of animals in seventeenth-century Europe also outlines how experimenters associated the palatability of animals

16. Justin Niermeier-Dohoney, "'Rusticall Chymistry': Alchemy, Saltpeter Projects, and Experimental Fertilizers in Seventeenth-Century English Agriculture," *History of Science* 60, no. 4 (Sep 2021): 1–29, <https://doi.org/10.1177/00732753211033159>; Sarah Lowengard, "Western Travelers Describe Foreign Textile Practices," *Technology's Stories* 7, no. 2 (13 Jun 2019): 1–11, <https://doi.org/10.15763/jou.ts.2019.06.13.03>

17. Meat is an obligatory passage point through which the historical understandings of many animal materials travel, from empirical studies of animal treatment and behavior to considerations of nutrition, political economy, climate, and the environment. We thank Alex Blanchette for encouraging discussion on this point. Noémie Vialles, *Animal to Edible* (Cambridge: Cambridge University Press, 2008); Alex Blanchette, *Porkopolis: American Animality, Standardized Life, and the Factory Farm* (Durham, NC: Duke University Press, 2020); Margaret Walsh, *The Rise of the Midwestern Meat Packing Industry* (Lexington: University Press of Kentucky, 2015).

with where and how they lived and what the animals themselves consumed.<sup>18</sup> Examples of improving livestock and other useful animals illustrate how new potentials for action open when humans “hack” animals, as described by historian Mark E. Frank, whether making the distinctive Tibetan yak more palatable, or leaner pigs more socially appealing in China.<sup>19</sup> In the history of biology, Dominic Berry has highlighted how mid-twentieth-century scientists used animal materials like the entrails of livestock, herring sperm, and cod liver oil to make DNA nucleosides, the “raw material” for synthesizing DNA.<sup>20</sup> In a more explicit example, philosopher Rom Harré used the Gibsonian concept of affordance to discuss how natural philosophers and modern chemists understand the chemical relationship of parts and wholes. Harré pointed out that by maintaining a cognizance of chemical affordances, it becomes ever more possible to understand how to avoid conflating things or properties with others, when one of those is a subfunction of a larger entity responsible for a major function. By extension, he explained that scientists are not simply fascinated by affordances but rather by the possibility that more affordances will come of the original entity.<sup>21</sup> For the material affordance of animals, similarly, the properties of things can be considered as endpoints that direct us historians to return our gaze to the original entity, the animal body, and study it as a generator of inquiries.

The contributions in this special issue focus on animals as sources of changing materials and technologies, contrasting with the whole, living, brain-endowed sentient organism exercising skills of cognitive perception. Our view of affordances underscores the interrelatedness of human makers, animals, and environments that enriches the historical method of studying knowledge production. Our research collectively explores how to study changing animal materials and gain tactile and other sensory insights into techniques of rendering animal materials.

18. Anita Guerrini, “A Natural History of the Kitchen,” *Osiris* 35, no. 1 (2020): 20–41.

19. Mark E. Frank, “Hacking the Yak: The Chinese Effort to Improve a Tibetan Animal in the Early Twentieth Century,” *East Asian Science, Technology, and Medicine* 48 (Jun 2018): 17–48; Sigrid Schmalzer, “Breeding a Better China: Pigs, Practices, and Place in a Chinese County, 1929–1937,” *Geographical Review* 92, no. 1 (2002): 1–22.

20. Dominic J. Berry, “Making DNA and Its Becoming an Experimental Commodity,” *History and Technology* 35, no. 4 (2019): 374–404.

21. Rom Harré, “Mereological Principles and Chemical Affordances,” in *Philosophy of Chemistry: Growth of a New Discipline*, ed. Eric Scerri and Lee McIntyre (Dordrecht: Springer Netherlands, 2015), 107–19.

“Rendering” is understood here as the transformation of animal materials into more-than-animal materials. By engaging design history, anthropology of techniques, and history of science, we ask, for instance, what knowledge could be afforded through the reproduction of techniques used to render animal fat.<sup>22</sup> The approach of reconstructing craft processes is a known method of gaining access to the mental worlds of historical actors in early modern European history,<sup>23</sup> but written manuals, recipes, and visual sources have not always played as central a role for the history of animal materials spanning multiple regions.

By emphasizing material affordances as materials and objects’ properties, which are simultaneously changeable, relational, and temporal, our approach shows that the process of making animal materials is coupled with making *histories* of animal materials. Animals serve as material boundary objects that allow us to ferret out historical reciprocities between craft knowledge and scientific knowledge.<sup>24</sup> This double methodology of making establishes an inclusive route for thinking ethically about animal bodies within the scope of knowing materials in history. Examining animal materials in this sociohistorical topography opens up a different perspective on the legacy of colonialism and empire in the history of the exploitation of natural resources and of the perpetuation of socioeconomic inequalities through time.

Our working concept of “material affordances” clears the ground to write new histories from the point of view of the knowledges engendered within communities that have been overlooked or exploited in the name of industrialization and science conducted within their colonial or neocolonial contexts.<sup>25</sup> In doing so, our modified take on affordances helps us move

22. See Sarah Lowengard, “On the Disappearance of the Animal Body: Animal Fat, Tallow, Candles, Soap, and Chemistry before 1830,” this issue.

23. Pamela H. Smith and The Making and Knowing Project, “Historians in the Laboratory: Reconstruction of Renaissance Art and Technology in the Making and Knowing Project,” *Art History* 39, no. 2 (2016): 210–33.

24. Sungook Hong, “Historiographical Layers in the Relationship between Science and Technology,” *History and Technology* 15, no. 4 (1999): 289–311; Susan Leigh Star and James R. Griesemer, “Institutional Ecology, ‘Translations’ and Boundary Objects: Amateurs and Professionals in Berkeley’s Museum of Vertebrate Zoology, 1907–39,” *Social Studies of Science* 19, no. 3 (Aug 1989): 387–420.

25. Examples of colonial and neocolonial strategies of belittling and marginalizing Africa and Africans, for instance, have inhibited understandings about the high degrees of knowledge about chemistry stemming from ancient Africa. See Gloria Emeagwali, “Intersections between Africa’s Indigenous Knowledge Systems and History,” in *African Indigenous Knowledge and the Disciplines*, ed. Gloria Emeagwali and George J. Sefa Dei (Rotterdam: SensePublishers, 2014), 1–18.



beyond the original trappings that connected perception to facile assumptions about a self-evident range of scientific processes. Specifically, our stance on material affordances opens up a range of spatiotemporal possibilities about making animal materials while contextualizing practice within specific communities. The relational emphasis of material affordances allows us to underpin the ethics of knowledge production to sociocultural phenomena that are made apparent when the focal analysis of the history of science is directed to the making of animal materials.

In the following two sections, we present a detailed overview of material affordances relative to knowing animal materials alongside a framework for their historical study. We briefly discuss animal slaughter as an obligatory passage point for analyzing the practical development of these materials. Since our analyses of animal materials operate across spatiotemporal scales, from the microscale of substances and animal bodies to the macroscale of craft processes and commercial decision making, we consider how to use animal materials to cast histories of biological materials that can center historically under-noticed human cultures, techniques, and processes. From this vantage, we present a framework including biological tissues, life cycles, craft processes, and materials science for contemplating the making of animal materials in time.

## THE AFFORDANCES OF ANIMAL MATERIALS

Making animal materials illuminates the importance of tracking dynamic change while interrogating the tension between what seems like opportunity on the one hand and biological or technological determinism on the other. Various definitions of “materials” exist, from the elements or substances that physically constitute something, to the intellectual resources or data that are used to compose a body of work, such as a report or a book. Here, we define “materials” as shaped and therefore bounded entities made of matter, and we also jointly consider materials as things that are iteratively detectable through processes of noticing their active properties and qualities. By virtue of the sociocultural embeddedness of these processes, we also emphasize that materials are both technological and political. This is particularly exemplified when parts of any given whole animal body undergo a plurality of states, guided by craft and scientific processes of recomposition. Craftspeople and scientists working with animal materials intuitively follow the affordances of these

materials in their actions.<sup>26</sup> Furthermore, owing to their properties, animal materials may also have a physical and/or psychological and emotional impact on the artisans.

Recent efforts to theorize the continuity of craft processes involving animal materials over the *longue durée* have pointed to the methodological challenges of historicizing such processes from practical perspectives alone. Meanwhile, embodied qualitative methods have fruitfully adjusted preconceptions of the unproblematic linear reproducibility of artisanal, secret, and craft knowledge as described in pre- or early modern manuals.<sup>27</sup> Historical studies of knowledge linked to materials often emphasize an interdisciplinarity that unites knowledge of the mind (conveyed via representations and texts) with that of the body. This scholarship has also highlighted the specific placeness of the production of knowledge that has been examined in histories of experiments vis-à-vis artisanal processes occurring in laboratories, workshops, kitchens, bakeries, and breweries.<sup>28</sup> Indeed, artisanal knowledge has been integral to the making of scientific knowledge, as is shown by disciplinary histories of science, including chemistry, engineering, and materials science.<sup>29</sup> As historian Lorraine Daston has pointed out, materials and meanings come together through the

26. Duarte Araújo et al., “Affordances Can Invite Behavior: Reconsidering the Relationship between Affordances and Agency,” *New Ideas in Psychology* 30, no. 2 (2012), 250–58. Tim Ingold uses the expression “intuition in action” in *Being Alive: Essays in Movement, Knowledge and Description* (London: Routledge, 2011), 211.

27. Merle Patchett, “The Taxidermist’s Apprentice: Stitching Together the Past and Present of a Craft Practice,” *Cultural Geographies* 23, no. 3 (2016), 401–19; Angela N. H. Creager, Mathias Grote, and Elaine Leong, “Learning by the Book: Manuals and Handbooks in the History of Science,” *BJHS Themes* 5 (2020), 1–13.

28. Robert E. Kohler, *Landscapes and Labscapes: Exploring the Lab-Field Border in Biology* (Chicago: University of Chicago Press, 2002); Pamela H. Smith, *The Body of the Artisan: Art and Experience in the Scientific Revolution* (Chicago: University of Chicago Press, 2004); Sven Dupré, ed., *Laboratories of Art: Alchemy and Art Technology from Antiquity to the 18th Century* (Cham: Springer, 2014); Simon Werrett, *Thrifty Science: Making the Most of Materials in the History of Experiment* (Chicago: Chicago University Press, 2019); Anita Guerrini, “A Natural History of the Kitchen,” *Osiris* 35, no. 1 (2020): 20–41.

29. Jan Golinski, *Making Natural Knowledge: Constructivism and the History of Science* (Chicago: University of Chicago Press, 2005); Bernadette Bensaude-Vincent, “The Construction of a Discipline: Materials Science in the United States,” *Historical Studies in the Physical and Biological Sciences* 31, no. 2 (2001): 223–48; Ann Johnson, “Material Experiments: Environment and Engineering Institutions in the Early American Republic,” *Osiris* 24, no. 1 (2009): 53–74; Cyrus C. M. Mody and Hyungsub Choi, “From Materials Science to Nanotechnology: Interdisciplinary Center Programs at Cornell University, 1960–2000,” *Historical Studies in the Natural Sciences* 43, no. 2 (2013): 121–61.

convergence of metaphysical, anthropological, and evidentiary interpretative grappling with things that compel us to act and think based on their self-evident truths or their projected messages.<sup>30</sup> Here, we delve further into these juxtapositions and reciprocities in narratives involving the moving target of animal materials.

Specifically, we define the changing nature of animal materials as known through a broad range of qualitative and quantitative biological, chemical, and mechanical properties. Such material properties of animal materials, or “animal materialities,” as we abbreviate, lead us to propose that these cues constitute the affordances of enduring or ephemeral animal materials that craft people and scientists detected through their perceptual engagement. Not only may novel uses of animal materials arise on the basis of the perceived material’s cues, but animal materials may also be transformed through time by humans into new materials and things in specific places such as laboratories and workshops that afford such changes in animal materials to occur through thought and practice. Following this, we view material properties as things grounded into social environments and historical contexts in which animal materials are produced and imbued with political significance.

The topic of animal materials in the humanities directs attention to how the extensive extraction and exploitation of raw materials in the colonial era has led to the depletion, extinction, or endangerment of species across the globe, thereby having a drastic impact on the identities, lifestyles, and local economies of diverse peoples. Inquiries into animal materials certainly invite discussions about ethics, identity, and agency that often feature in animal studies that critique hierarchies of exception that subjugate specific groups of humans as animal. As feminist historical literary scholar Kyla Wazana Tompkins has noted, we have a responsibility to recognize the epistemologies and ontologies that are familiar to “humans who have never been quite human enough.”<sup>31</sup> Awareness that our myopic emphasis on animals and microscale processes could inadvertently reproduce the marginalization of people involved in broader historical processes raises a serious challenge for thinking about how

30. Lorraine Daston, *Things That Talk: Object Lessons from Art and Science* (Cambridge, MA: Zone Books, 2008), 12–13.

31. Kyla Wazana Tompkins, “On the Limits and Promise of New Materialist Philosophy,” *Lateral* 5, no. 1 (Spring 2016), <https://doi.org/10.25158/L5.1.8>; Zakiyyah Iman Jackson, “Animal: New Directions in the Theorization of Race and Posthumanism,” *Feminist Studies* 39, no. 3 (2013): 669–85; Kelly Struthers Montford and Chloë Taylor, eds., *Colonialism and Animality: Anti-Colonial Perspectives in Critical Animal Studies* (London: Routledge, 2020).

objective examinations of and discussions on animal materials could make histories of science more inclusive. While animalization can refer to the processes of preparing textiles to take up particular dyes, the essays in this special issue do not confront how people become dehumanized through a process of “animalization.”<sup>32</sup>

Further, provenance issues in material heritage and decolonization discourse have attracted the attention of animal history scholars who strive to newly analyze collections and archives reflexively in order to spur genuine change and rethinking what scholarship is for, and for whom.<sup>33</sup> Our project is sympathetic to these developments while maintaining a tight focus on the concept of material affordances. This focus helps us to notice the potentialities of animal materials as directly perceived by humans and emerging from creative and scientific processes of making animal things within specific sociocultural and historical contexts.<sup>34</sup> At the same time, we recognize that the animal materials themselves become socioculturally embedded when being made, used, and interpreted.<sup>35</sup> In doing so, we show the importance of an analytical repertoire

32. For discussions of “animalization,” see Neel Ahuja, “Postcolonial Critique in a Multi-species World,” *PMLA* 124, no. 2 (2009): 556–63. See also Mel Y. Chen, *Animacies: Biopolitics, Racial Mattering, and Queer Affect* (Durham, NC: Duke University Press Books, 2012); Jay Geller, *Bestiarum Judicium: Unnatural Histories of the Jews* (New York: Fordham University Press, 2017); Juno Salazar Parreñas, *Decolonizing Extinction: The Work of Care in Orangutan Rehabilitation* (Durham, NC: Duke University Press, 2018).

33. Nicholas Jardine and Lydia Wilson observe a revival in the use of botanical and zoological collections for research purposes, for instance in biodiversity studies, over the past twenty years. See their “Introduction: Recent Material Heritage of the Sciences,” *Studies in the History and Philosophy of Science* 44, no. 4 (2013): 632–33. See also the activities of Collection Ecologies: Histories, Environments & Circulations, <https://collecte.hypotheses.org>; Chakanetsa Mavhunga, “Towards an African Technological & Scientific Imaginary,” 10 Dec 2019, in *Decolonization in Action*, podcast, [www.decolonizationinaction.com/episodes/2019/12/10/episode-6](http://www.decolonizationinaction.com/episodes/2019/12/10/episode-6); Sarah Van Beurden, “The Art of (Re)Possession: Heritage and the Cultural Politics of Congo’s Decolonization,” *The Journal of African History* 56, no. 1 (2015): 143–64; Paul Basu and Ferdinand de Jong, “Utopian Archives, Decolonial Affordances: Introduction to Special Issue,” *Social Anthropology* 24, no. 1 (2016): 5–19; Mathilde Cohen, “Animal Colonialism: The Case of Milk,” *AJIL Unbound* 111 (2017): 267–71; Billy-Ray Belcourt, “Animal Bodies, Colonial Subjects: (Re)Locating Animality in Decolonial Thought,” *Societies* 5, no. 1 (2015): I–II.

34. As shown by anthropologists of techniques who see the concept of affordances as both material and cultural. See Myriem Naji, “Le fil de la pensée tisserande,” *Techniques & Culture* 52, no. 3 (2009): 68–89; Sandra Revolon, “Iridescence as Affordance: On Artefacts and Light Interference in the Renewal of Life Among the Owa (Eastern Solomon Islands),” *Oceania* 88 (2018): 31–40.

35. Although not all of our historical cases employ direct observation of such embodied practices about materials, we want to draw our readers’ attention to the importance of bodily and

grounded historically on animal materials and how that should, in turn, allow a wider swath of scholars across the sciences and humanities to consider how the strict physicality of these materials must be grasped by reflecting on their embeddedness in human cultures of doing creative investigative work—whether it is labeled craft, technical, scientific.

Animal materials constitute a distinct kind of material that prompts the need to ask historical questions about the knowledges embodied in the human hands and minds who do the work of mediating or observing the transformations of this material. Inquiries into animal materials by necessity lay bare the question of where historical agency resides, especially as biological and non-biological things intermingle.<sup>36</sup> The practical and intellectual tensions raised by neomaterialist discussions about bodies and environmental elements challenge us to look more closely at the historical analysis of animal materials. In this issue, authors occasionally use the term “materiality” to highlight these lively and active properties of animal materials in connection to the spatial and temporal contexts wherein the animal material undergoes transformative processes situated within human-scale material practices. When people transform animal materials, they may find themselves transformed physically, spiritually, or psychologically. This reciprocity complicates assumptions that either conflate materials with resources or regard the term “material” more as an adjective than a changeable thing.<sup>37</sup> Their materiality—the sensorily experienced and imagined properties of materials over time—defines how they function as materials that distinctly afford the means to build different identities, classes, labor organization, and social values in specific ways. While recognizing the rich Marxist discourse on historical and dialectical materialism that has informed critical scholarship about ontologies of materiality, we do not engage with this approach. Rather than focusing on commodification as an endpoint,

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sensory perceptions of animal materials, as well as the configurations and arrangements involved in making them, as has been suggested in the anthropology of craft and design and, more broadly speaking, in material culture studies and social-cultural anthropology.

36. The neomaterialist scholarship of LeCain illustrates the creative and destructive contributions of nonhumans for understanding the intersection of environment, industry, and animal health. Timothy J. LeCain, *The Matter of History: How Things Create the Past* (Cambridge: Cambridge University Press, 2017). See also Jane Bennett, *Vibrant Matter: A Political Ecology of Things* (Durham, NC: Duke University Press, 2009).

37. Hans Peter Hahn, “Kinds of Resources and Ways of Perceiving: Anthropological Reflections on a Contested Category,” in *ResourceCultures: Sociocultural Dynamics and the Use of Resources—Theories, Methods, Perspectives*, ed. Anke K. Scholz, Martin Bartelheim, Roland Hardenberg, and Jörn Staecker (Tübingen: Universitätsbibliothek Tübingen, 2017), 35–44.

our historical and conceptual approach is grounded in specific case studies about materials. This method allows us to articulate some of the subtle and various ways in which animal materials are rendered into things and assigned different kinds of values within processes of “making.”

## A TIME AND PLACE FOR A HISTORY OF ANIMAL MATERIALS

Over the last two decades, historians have shifted from studying human–animal boundaries and animals in environmental history to recognizing specific animals as historical subjects.<sup>38</sup> As such, the bounds of animal histories undergo a stress test as we consider how human historical actors understood the recomposition of animal body parts as materials by deemphasizing whole living organisms.<sup>39</sup> Going a step beyond the history of animals implicated in meatpacking or provisioning, animal histories can be known through another facet: the material properties of animal materials as they undergo changes related to industrial processes, as well as the generation or maintenance of different forms of value.<sup>40</sup>

The processing of animal materials can be explored as part of wider attempts to understand the *longue durée*. The “reactivation” of remains, or so-called

38. For example, see Angela N. H. Creager and William Chester Jordan, eds., *The Animal–Human Boundary: Historical Perspectives* (Rochester: University of Rochester Press, 2002); Virginia DeJohn Anderson, *Creatures of Empire: How Domestic Animals Transformed Early America* (Oxford: Oxford University Press, 2010); Etienne Benson, *Wired Wilderness: Technologies of Tracking and the Making of Modern Wildlife* (Baltimore, MD: Johns Hopkins University Press, 2010); Marcy Norton, “The Chicken or the Iguana: Human–Animal Relationships and the Columbian Exchange,” *The American Historical Review* 120, no. 1 (2015): 28–60; Susan Nance, ed., *The Historical Animal* (Syracuse, NY: Syracuse University Press, 2015); Rohan Deb Roy, *Malarial Subjects: Empire, Medicine and Nonhumans in British India, 1820–1909* (Cambridge: Cambridge University Press, 2017); Dolly Jørgensen, *Recovering Lost Species in the Modern Age: Histories of Longing and Belonging* (Cambridge, MA: MIT Press 2019).

39. Indeed, historians have demonstrated the important use of animals as well as plants in the study of chemistry in Europe. See, for instance, Ursula Klein and Wolfgang Lefevre, *Materials in Eighteenth-Century Science: A Historical Ontology* (Cambridge, MA: MIT Press, 2007), 232–44.

40. William Boyd, “Making Meat: Science, Technology, and American Poultry Production,” *Technology and Culture* 42, no. 4 (2001): 631–64; Roger Horowitz, *Putting Meat on the American Table: Taste, Technology, Transformation* (Baltimore, MD: Johns Hopkins University Press, 2005); Jeffrey M. Pilcher, *The Sausage Rebellion: Public Health, Private Enterprise, and Meat in Mexico City, 1890–1917* (Albuquerque: University of New Mexico Press, 2006); Edmund Russell, “Introduction: The Garden in the Machine: Toward an Evolutionary History of Technology,” in *Industrializing Organisms: Introducing Evolutionary History*, ed. Susan R. Schrepfer and Philip Scranton (New York: Routledge, 2004), 1–16.

dead animal materials, by scientists and craftspeople are not merely historical actions requiring historical reconstruction or contextualization within de-extinction.<sup>41</sup> The specific processes that guide animal materials to enter new arrangements and forms straddle the lively bodies of animals and their afterlives. Histories of environmental waste and externalities from agriculture and industry indicate how and why the derivation of animal materials from animal remains is a topic of wide scholarly and public interest.<sup>42</sup> Rendering activities exceed conventional life-cycle endpoints and thus demand a deeper analysis of the relationship between animal beings and material artifacts. The study of animal materials contrasts two histories of animal remains: one as salvageable things, and another as harmful waste and effluents.<sup>43</sup> Our attention to the rendering that results in animal materials does not include all kinds and states of biological decay. The processes of making animal materials are only knowable in conjunction with how historical actors have perceived their potential and obsolescence. Researchers can still do much to shed light upon the history of using animal remains.

The case studies comprising this special issue highlight a range of critical turning points in which shells, fats, ivories, pearls, hides, bones, scales, and other animal materials are conceptualized or transformed into something new, in and beyond the fields of biomedicine and materials science engineering. While employing analytic methods grounded in the historical study of animals, the authors focus on the processes that afford critical, conceptual, and theoretical perspectives into the study and making of new animal materials. The terminologies and semantics employed by the human historical actors featured in this issue show how worldviews and geographies inform the making of animal materials and knowledges. The contributors highlight the conceptual significance of terms used in both local and scientific contexts to refer to animal

41. Sandra Swart, "Resurrection Conservation: The Return of the Extinct?," in *Nature Conservation in Southern Africa*, ed. Jan-Bart Gewald, Marja Spierenburg, and Harry Wels, 130–64 (Leiden: Brill, 2018).

42. Donna Jeanne Haraway, "Awash in Urine: DES and Premarin<sup>®</sup> in Multispecies Response-ability." *WSQ: Women's Studies Quarterly* 40, no. 1 (2012): 301–16.

43. D. Ramalingam, "A Study on the Effects of Leather Industry in Tiruchirappalli, Tamil Nadu," *Proceedings of the Indian History Congress* 77 (2016): 1008–15; Wilson J. Warren, "A Plague of Pigs and Other Environmental Dilemmas," in *Meat Makes People Powerful: A Global History of the Modern Era* (Iowa City: University of Iowa Press, 2018), 148–60. Studies of pollution raise serious points about the difficulty of ignoring the environmental dimension of making and using animal materials.

materials and substances that are culturally and, more specifically, historically loaded, since they reflect the practices of their times.<sup>44</sup>

The six articles serve collectively as a framework for interrogating the fragile line between natural and artificial life, substances, and products, and for shedding a unique light upon the dual making of animal materials and knowledge of animals along different spatiotemporal scales. Starting with biological tissues, the articles bring together topics such as composition, life cycles, craft processes, and materials science in order to strengthen understandings of different analytical and manufacturing processes. Following the changing properties of animal materials allows for an examination of knowledge, techniques, and material processes that outlines the opportunity for new historiographical understandings that stretch across, within, or from the borders of the life sciences into other spheres of knowledge.

### Biological Tissues

As Georges Canguilhem once remarked, the study of tissues that predated the development of cell theory in the eighteenth century emphasized the woven continuity of life as something knowable and appreciated by haptic sensation. Biological tissues, in this sense, prompt thinking about the organization of things, actions, and intentions that compose relationships.<sup>45</sup> The flesh of animals, which often serves as the entry point for contemplating tissues, importantly tests our assumptions about what tissues are and ought to be. And, as historian Karen Senaga has shown of the defiant taste of catfish that twentieth-century aquaculturists sought to erase, perceptions of those tissues beyond tactility alone have informed human experiences and desires, leading to shifts in their interactions with animal others.<sup>46</sup> Rather than see sensory ways of knowing as a primitive passage point en route to more sophisticated scientific methods, dwelling upon tissues reminds us to recognize how knowledge connected to them are both material and relational.

44. Cliff Goddard, "Words as Carriers of Cultural Meaning," in *The Oxford Handbook of the Word*, ed. John R. Taylor (Oxford: Oxford University Press, 2015), 380–98.

45. Georges Canguilhem, *Knowledge of Life*, trans. Stefanos Geroulanos and Daniela Ginsburg (New York: Fordham University Press, 2010), 43.

46. Karen Senaga, "Muddy to Clean," in *New Materials: Towards a History of Consistency*, ed. Amy E. Slaton (Amherst, MA: Lever Press, 2020), 39–72. Such studies of new animal materials inform perceptions about the distribution of goods and resources, understandings of how class and race reflect sociocultural choice-making and ideas about animal materials.



The articles in this special issue especially bring attention to biological tissues as locations across different levels of substances that serve as sites of various processes. More specific than the whole animal body and not disembodied or rendered so thoroughly as to be regarded as an animal substance, talk of tissues provides important baselines for understanding transformations in the fibers, flesh, and bones of animals that create new material assemblages that exist even beyond the animal body. For instance, Scott Gilbert examines oysters from the 1800s to the present as providers of calcium, human food, and water filtration. By tracing the emergence of triploid oysters and their tasty voluptuousness, Gilbert illuminates how biological changes correspond mutually to the dynamics of oyster networks of interactions amongst more-than-human concerns and human developments and historical contingencies. These lively, organismal tissues open up questions on how efforts to know or enhance the fleshiness of animals contrast with the activities cued by human curiosity about animal tissues that separate readily and steadily from the body. Irina Podgorny and Susanna V. García explore how European and North American natural historians in the eighteenth century examined the armature of armadillos and sought to differentiate between hair, skin, and nails. In doing so, they clarify how the study of a biological tissue gave momentum to animal chemistry techniques. The topics taken on by these papers lead to questions about the kind of processes that may follow upon the analysis of animal tissues.

### Recomposition

The notion of “composition” commonly describes a gathering of things under an aesthetic logic. Be they ideas or artifacts, things can be composed and—under ripe conditions—recomposed in the course of making things anew. Rendering processes such as repurposing and composting, for instance, highlight the porous boundaries between a given animal and its ecological and built environments, as well as links to the progression of time.<sup>47</sup> The rendering of animal tissues into other animal materials is complemented by a rhetorical rendering of human–animal relations into immaterial thought.<sup>48</sup> And, as the idea of scaffolding in reference to organismal development suggests, other

47. Donna Haraway, “Anthropocene, Capitalocene, Plantationocene, Chthulucene: Making Kin,” *Environmental Humanities* 6, no. 1 (2015), 159–65.

48. Animal studies scholar Nicole Shukin has pointed out that rendering animal remains have contributed to biopolitical discourse, for instance as the “mundane recycling” of animal remains are displaced by abstract understandings of life as genetic code or as images set in photosensitive

processes can engage with substances derived from living things to recompose materials.<sup>49</sup> Furthering this idea, the topic of recomposition invites an examination of how new meaningful arrangements are materially brought together by transgressing bodily borders.

The papers in this issue thus address how organisms, including humans, exploit animal materials to create scaffolding for new (animal) materials without making assumptions about a preexisting pristine nature. These papers advance a discussion of particular time and place in regards to how new animal materials gain instability in the face of decomposition, coexistence, or use. To develop this observation, Sarah Lowengard's essay emphasizes phase changes in animal fat—from tissue to liquid to solid—and from one useful substance to waste to another useful substance. Her paper demonstrates the process of recomposition by reexamining the eighteenth- and nineteenth-century history of how fat, a waste product of meatpacking, changed as a result of collection and purification processes in European soapmaking. Through the reexamination of familiar soapmaking instructions and, importantly, their execution, this example of recomposition points to the importance of the role of scale as the increased volume of available animal materials in new productive processes, especially relative to rising meat consumption, industrialization, and organic instrumental analysis. Following these instructional manuals herself has helped Lowengard identify a relationship between the specific spaces wherein animal materials, as they undergo a range of physical, biological, or cultural processes, are deemed worthy of notice, and the places where relevant scientific work is conducted. Alongside other papers in this special issue, especially those related to craft practices, stressing the temporality of processes within the discussion enable one to notice recomposition and its historical significance.

### Life Cycles

The life cycles of living things encompass molecular, cellular, chemical, and physical processes that converge in ways that have led scholars in different

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gelatin. Nicole Shukin, *Animal Capital: Rendering Life in Biopolitical Times* (Minneapolis: University of Minnesota Press, 2009), 28, 84, 110–11.

49. Georg Theiner proposed the concept of scaffold as a necessary, mediating structure and resource that can occasionally be removed, and James Griesemer discusses the different temporalities of scaffolds in the systems they contribute to. Linnda R. Caporael, James R. Griesemer, and William C. Wimsatt, eds., *Developing Scaffolds in Evolution, Culture, and Cognition* (Cambridge, MA: MIT Press, 2013), 1–20, 23–56; Andy Clark, *Being There: Putting Brain, Body, and World Together Again*, reprint edition (Cambridge, MA: A Bradford Book, 1998), 45–46.

cultures around the world to produce metaphors and imagery of life cycles and circulation. Recent discussions in the history of life sciences, environment, and medicine have shown how such discussions of cycles have helped demonstrate sexual or asexual reproductive cycles of living things, from microbes and mealworms to elephants, in addition to biogeochemical cycles of matter and elements, as well as ecological cycles governing individuals and populations.<sup>50</sup> While they are used to understand life itself, metaphors of circularity and life cycles may obfuscate or simplify complexity as they gain use to describe growing instances of human-driven technological cycles. As Romaniello, Smith, and Starks have written of the “life cycle of things,” it is crucial to recognize how the multivalence of things across space and time, including the afterlife of things, create distinctions between artefact, commodity, and product.<sup>51</sup> Put simply, life, spanning birth and design to death or obsolescence, can be thought of in a fashion different from the way siloed disciplines have typically permitted.

The endeavor to articulate how recomposition is involved in making animal materials relatedly injects a discussion of time and temporality into the framework for historicizing animal materials. The essays in this special issue take a step toward carving out space for exploring complicated outlines of interactions and movements among dynamic bodies, substances, technologies, and knowledge. Papers such as Kjell Ericson’s contribution on making pearls in Japan show the asymmetries in the interplay between invertebrate life stages and the contingent, temporal processes hinged to raft regulation and larval attachment, which interlocked the pursuit to reach spherically symmetric perfection with ideologies about how the marine environment of Ago Bay should work. Complementing Gilbert’s discussion of life cycles that centered on chromosome copies, Ericson’s focus on the science of nacreous animal materials promotes an awareness that cultivation cycles are not just created—they undergo aging processes that prompt a variety of adjustments, opportunities, and actions.

### Craft Processes

The location of the work where people envision and make things from animal bodies, fields, workshops, kitchens, or laboratories is integral to explicating the

50. A recent enriching discussion on cycles is featured in Nick Hopwood et al., “Cycles and Circulation: A Theme in the History of Biology and Medicine,” *History and Philosophy of the Life Sciences* 43, no. 3 (2021), article no. 89. <https://doi.org/10.1007/s40656-021-00425-3>

51. Matthew P. Romaniello, Alison K. Smith, and Tricia Starks, eds., *The Life Cycle of Russian Things: From Fish Guts to Fabergé, 1600–Present* (London: Bloomsbury, 2021), 3, 6.

centrality of craft processes in the transformation of animal materials. Recent discussions about the definition and analytic usefulness of materiality that have straddled archaeology and anthropology also map onto discussions of animals as materials with affordances.<sup>52</sup> Craft processes provide a starting point for inquiring into the technical means of diminishing the detectability of animal traces.<sup>53</sup> The analyses of craft processes applied to animal materials thus function to articulate animal–human relations in the overlap between making and studying as the activity spaces remain stationary or shift from workshop, field, kitchen, or laboratory. The topic of artisanal craft processes also illuminates how interests in properties have acted as a means of critiquing trends in material culture studies. For instance, Tim Ingold and others have examined the empirical properties of the materials constitutive of objects and how they change as a result of processes as a way to focus on materials that shape human culture, perception, and meanings.<sup>54</sup> Such materials provide affordances and constraints that shape how humans can think, feel, and act. More importantly, the changes that animal tissues and materials undergo as they are rendered through craft processes into new assemblages of chemical, physical, biological, properties, and values are detectable to the practiced eyes of craftspeople. As dynamic things in process, animal materials are never neutral, nor do they possess a universal, transhistorical meaning, which makes it key to focus on craft practices. Focusing on the nexus of informal spaces of knowledge production and conventional spaces of institutionalized science can achieve a deeper understanding of how various animal materials come into being. Acknowledging the rootedness of animal materials in bodily and craft processes is not only reflexive and ethical but methodological: it facilitates historical

52. Amade M'charek, "Fragile Differences, Relational Effects: Stories about the Materiality of Race and Sex," *European Journal of Women's Studies* 17, no. 4 (2010): 307–22.

53. Some scholars refer to these traces as "animality," which doubly corresponds to the characteristics of animals that can be assigned to the people who work with animal materials in a particular society, guild, caste system, or community of practice as they are transformed by the affordances of animal materials just as much as their work elicits changes in animal materials. Henry Hodges, *Artifacts: An Introduction to Early Materials and Technology* (New York: F.A. Praeger, 1964), 162–64; Mel Y. Chen, *Animacies: Biopolitics, Racial Mattering, and Queer Affect* (Durham, NC: Duke University Press Books, 2012).

54. Ingold's point is documented in Carl Knappett, "Materials with Materiality?," *Archaeological Dialogues* 14, no. 1 (2007): 20–23. See also Giovanni Aloï, "Following Materiality: From Medium to Surface-Medium Specificity and Animal Visibility in the Modern Age," in *Speculative Taxidermy: Natural History, Animal Surfaces, and Art in the Anthropocene* (New York: Columbia University Press, 2018), 161–90.

questions about the working assumptions exercised by human actors spanning different times and contexts.<sup>55</sup> Put another way, affordances allow insight into what craftspeople have done with the bodies of animals historically and across cultures.

Broadening historical understanding of making animal materials in craft and industrial practices, as exemplified by Sarah Teasley in this issue, shows that an attunement to temporality is crucial for identifying material affordances in relation to accounting for the eventual uses of animal materials. Teasley's consideration of the historically permissive use of animals such as fish and cows to make glue in mid-twentieth-century Japanese wood workshops offers a respite from the telos and hubris of human invention in histories of industry and commerce by contemplating the agency of animal materiality in relation to their affordances and fungibility in small-scale manufacturing. In highlighting the use and disuse of animal-based glues, their relationship with cultural and socioeconomic aversions to animal products, and the introduction of other types of adhesive technologies, Teasley articulates the intersection of everyday life and industrial processes.

### Materials Science Engineering

The history of efforts to understand and make new animal materials in workshops, laboratories, and other formal and informal spaces of experimentation presages what have come to be called biomaterials in the field of materials science engineering. The biological turn in materials science engineering is relatively new, posing an opportunity for theoretical and empirical inquiries about the artistry, craft, and expertise of making new materials and their affordances.<sup>56</sup> Twentieth-century developments centering on active biological matter such as membrane protein pumps have changed the materiality of biological matter in important ways, contributing to what Mathias Grote has

55. For example, in the way historians have a role to play in asking how naturalizing scientific narratives about antiquity have become prevalent. See Pratik Chakrabarti, *Inscriptions of Nature: Geology and the Naturalization of Antiquity* (Baltimore, MD: Johns Hopkins University Press, 2020), 8.

56. The transformative processes through which animal proteins, sugars, and minerals are constituted biologically and technologically form the conceptual backbone of the locally grounded ontological language used by scientists to discuss products inspired by animals, both figuratively and physically. Michaela Eder, Amini Shahrouz, and Peter Fratzl, "Biological Composites—Complex Structures for Functional Diversity," *Science* 362, no. 6414 (2018): 543–47.

called its molecular-mechanical character, in which the components of life are taken apart and reassembled more easily than ever before.<sup>57</sup> Materials chemists and materials science engineers have avidly drawn from disparate scientific fields to explore and reconstruct biomimetic processes. New evidence from the biological turn in materials science indicates that the aforementioned notion of active matter continues to change as it is used to explain phase changes in the materials and how these changes relate to their structure and environment.<sup>58</sup> Yet, arguments about the naturalness of new materials or products and a fixation on the past—an origin—requires a historical contextualization that departs from institutional and laboratory histories that emphasize doing biology, chemistry, or physics. As scientists have increasingly described new materials in historical and natural terms and as materials science engineering interests in biomaterials benefit politically from foregrounding naturalness,<sup>59</sup> animal materials can be analyzed as boundary objects that traverse different social worlds. Acknowledging the opportunism connected to animal materials offers another view of the significance of material affordances that emerges through the study of craft processes. Examining the practical interests that operate on both technical and social levels clears a way to a genealogy of the research field.

Animal tissues like scales, nails, bones, and teeth are useful for elucidating the historical emergence of biological materials research in materials science

57. Mathias Grote, *Membranes to Molecular Machines: Active Matter and the Remaking of Life* (Chicago: University of Chicago Press, 2019), 113–16, 186–88. For a discussion of “matter in action,” see also Daniel Liu, “The Artificial Cell, the Semipermeable Membrane, and the Life that Never Was, 1864–901,” *Historical Studies in the Natural Sciences* 49, no. 5 (2019): 504–55.

58. Peter Fratzl, Michael Friedman, Karin Krauthausen, and Wolfgang Schäffner, eds., *Active Materials* (Berlin: De Gruyter, 2021); Skylar Tibbitts, ed., *Active Matter* (Cambridge, MA: MIT Press, 2017); Peter Fratzl, “Biomimetic Materials Research: What Can We Really Learn from Nature’s Structural Materials?,” *Journal of the Royal Society Interface* 4, no. 15 (2007): 637–42.

59. This is often done with the aim of aligning them in the public eye with sustainable and ecological processes. Historians have analyzed the dichotomous concepts of art and nature in order to explore different interpretations of the artificial and the natural. Bernadette Bensaude-Vincent and William R. Newman, eds., *The Artificial and the Natural: An Evolving Polarity* (Cambridge, MA: MIT Press, 2007), 9. The alignment of biomaterials with the concepts of nature and the natural make the new materials more appealing to the public, compared for instance to nanotechnology, at least within the U.S. institutional context. This development of (nano-)biomaterials and the emergence of a language of “biomaterials” in the 1960s and 1970s are discussed in the *Encyclopedia of the History of Science*, s.v. “Materials Science,” by Cyrus Mody and Joseph Martin. <https://doi.org/10.34758/6afy-woo6>

and engineering literature.<sup>60</sup> The increased awareness of how bodies became known as “biological” raised through feminist materialist discourse on science over the last several decades has also provided a unique perspective for some of the contributors to this issue.<sup>61</sup> Marianna Szczygielska illuminates the work of researchers, such as museum conservators and forensics researchers, who worked with the teeth of extant and extinct mammals. Her employment of a refractive reading of the optical properties of teeth shows how historicizing the visual standards used for identifying elephant species necessarily interrogates how the manufacture of ivory objects came to embody ideals of whiteness that also promoted certain ideals of race, gender, and class. Podgorny and García’s study on collecting and testing South American armadillo carapaces during the same era additionally provides insights about the significance of nineteenth-century animal materials research for elucidating how efforts to hone new scientific methods and techniques to study their material properties reflected and magnified scientific fascination with the naturally protective carapace of the mammal and laid the ground for understanding the beginnings of biomaterials research.

## CONCLUSION

Ultimately, the articles in this issue demonstrate that scholars of animal materials can explicate underknown epistemological contexts. Critical and reflexive use of the concepts of material affordances to historicize the rendering processes that have featured in the making of high-profile and mundane animal materials allows us to interrogate how animals and humans co-construct materials, and thus inquire into the joint natural and cultural processes by which

60. Sergey V. Dorozhkin, “A Detailed History of Calcium Orthophosphates from 1770s till 1950,” *Materials Science and Engineering: C* 33, no. 6 (2013): 3085–110.

61. Donna Haraway, *Simians, Cyborgs, and Women: The Reinvention of Nature* (New York: Routledge, 1991), 164; Hannah Landecker, “Between Beneficence and Chattel: The Human Biological in Law and Science,” *Science in Context* 12, no. 1 (1999): 203–25. A discussion of HeLa cells and extracted human cell lines at the heart of “Moore v. Regents of the University of California” exemplifies this point. Donna J. Haraway, *Modest\_Witness@Second\_Millennium. FemaleMan\_Meets\_OncoMouse: Feminism and Technoscience* (Routledge, 1997), 142. Feminist science studies point to the concrete material connections among spaces, temporalities, and practices that prompt inquiries about what in the materiality of bodies makes them “susceptible to the enactment of biological and historical forces simultaneously.” Karen Barad, “Posthumanist Performativity: Toward an Understanding of How Matter Comes to Matter,” *Signs* 28, no. 3 (2003): 801–31, on 809.

humans have used animals historically. Animal materials offers a complicated yet powerful framework for understanding the history of science, connecting craft to the history of materials science engineering. Foregrounding animal materials or materialities has moved existing conversations beyond the binaries of dead or alive, and natural or artificial, to consider the substantive, nonlinear, and dynamic matter of animals while striving to avoid essentialist sins that might suggest that all roads lead to extractive neocolonial endpoints that disown and exclude historical owners of practical knowledge.

The cases discussed in this issue are by no means exhaustive. They have been selected to encourage a rethinking of familiar processes, be they biological, cultural, or physical, and to inquire into how these involve rendering animals into materials treated as temporal entities. These cases of making animal materials do not all stress material affordances with the same weight, nor do they all agree on the application of the concept, but taken together they model an inclusive style of questioning and of noticing the production and legitimacy of knowledges. The tension of thinking about disciplinary futures in relation to endeavors to retrace the making of animal materials is a productive one that should inspire scholars to look even further back in time as well as in different communities and species, and in doing so, create channels for exchanging ideas within the humanities and social sciences. The time could not be more ripe for historians of science to engage in the critical studies of making animal materials.

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