Scott Curtis

Animated Images in a Media History of Science

Animation has been used in science and medicine since the 1910s and is ubiquitous today, when nearly every scientific discipline uses animation to test and/or communicate results. Animation is only one of many representational technologies used in these fields, a range that includes everything from pencils to electron microscopes. If we were to focus on animation's unique place in that ensemble, however, a number of questions emerge: Why animation? What value does it hold for researchers? How is that value expressed in practice? How did these practices and values develop over time?

Scholars in the philosophy, sociology, and history of science explore similar questions and themes in scientific practice. Philosophers of science ponder questions of epistemic value: What role do diagrams play in biological reasoning, for example? How do they contribute to scientific knowledge?[1] Sociologists of science observe the ways that researchers use their tools in the laboratory: How do they employ computer modeling, for example, in their routine representations of proteins?[2] Historians of science are interested in the development of these visualization practices: How can we trace the emergence of a visual culture in science, such as the use of drawings and notations in astronomers' notebooks of the nineteenth century?[3]

1 See Laura Perini, "Explanation in Two Dimensions: Diagrams and Biological Explanation," *Biology and Philosophy* 20 (2005): 257–269; and Nicola Mößner, *Visual Representations in Science: Concept and Epistemology* (London: Routledge, 2018).

2 See Natasha Myers, *Rendering Life Molecular: Models, Modelers, and Excitable Matter* (Durham, NC: Duke University Press, 2015). For a fine sampling of current work in this area, see Catelijne Coopmans, Janet Vertesi, Michael Lynch, and Steve Woolgar, eds., *Representation in Scientific Practice Revisited* (Cambridge, MA: MIT Press, 2014).

3 See Omar W. Nasim, *Observing by Hand: Sketching the Nebulae in the Nineteenth*

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Each discipline speaks to the others, as their questions and approaches overlap, but these questions are also important to anyone interested in what we might call a *media history of science*: a history that focuses on the role of media in scientific knowledge production and dissemination. Such a focus implies a mutually constitutive relationship between medium and discipline and challenges us to describe that relationship historiographically. I have argued elsewhere that, to understand the use of any given medium for any given discipline, we must find points of contact between the material limits and possibilities of the medium—its *form*—and the agendas and practices of the discipline.[4] Cinema and media scholars are especially adept at articulating a medium's formal properties, but we should draw on the established literature in the philosophy, sociology, and history of science—often, but not always, aligned with the field known as science and technology studies (STS)—to understand disciplinary agendas and practices.

Recognizing that *animation* and *science* are umbrella terms that cover a wide range of practices and agendas—the specificities of which any historical case study would need to address—I nevertheless think it would be helpful to outline how these broad questions about value, practice, and history can help us articulate the role animation might play in this media history of science. In what follows, I will look at the philosophical and historiographical questions specifically: What epistemic value does animation hold for science? How do we explore the twentieth-century emergence of animation in scientific visual culture? Finally, I will address the question of why cinema and media scholars should consider science a vital area of inquiry.

What is animation's role in the process of knowledge production? Philosophers of science have not asked this question of animation directly, but they have asked it of figures, diagrams, graphs, and models, all of which bear a family resemblance to animation. Understanding the value of images (as opposed to text) in science can help us begin to understand the epistemic value of animation, even if it adds dimensions that diagrams and such do not.

Generally speaking, the philosophy of science divides the epistemic work of scientific representations into two tasks: explaining and exploring.[5] When scientists explain ideas or results, visual representations perform valuable work by offering more than the written word can: most diagrams, for example, provide information about the spatial arrangement of the object under study that sentences cannot easily replicate.[6] Even tables and graphs arrange their data spatially to deliver their information more efficiently than written explanations. Yet while they may depict the arrangement of objects in space,

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Century (Chicago: University of Chicago Press, 2013). On the emergence of visual cultures in science, see Klaus Hentschel, *Visual Cultures in Science and Technology: A Comparative History* (Oxford: Oxford University Press, 2014).

4 Scott Curtis, *The Shape of Spectatorship: Art, Science, and Early Cinema in Germany* (New York: Columbia University Press, 2015), especially the introduction and conclusion.

5 See Mößner, *Visual Representations*, 7.

6 See Laura Perini, "Scientific Representation and the Semiotics of Pictures," in *New Waves in Philosophy of Science*, ed. P. D. Magnus and Jacob Busch (Basingstoke, UK: Palgrave Macmillan, 2010), 131–154; and Laura Perini, "Diagrams in Biology," *Knowledge Engineering Review* 28, no. 3 (2013): 273–286.

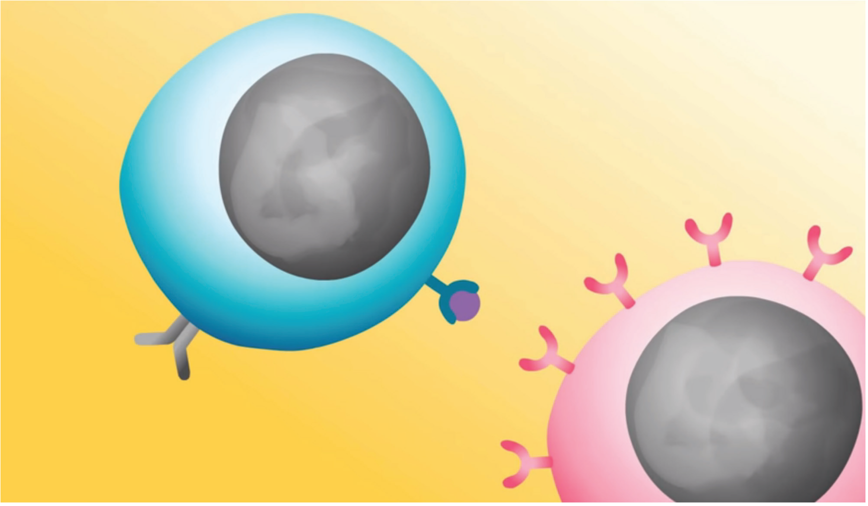

Figure 1. A helper T cell (lower right) seeks to bind with the antigen (small circle in the center) on a B cell (upper left) (Wellcome Trust, 2015).

diagrams present only the information necessary at the moment, thereby abstracting important details from the wealth of data found in, say, a photograph.[7] A diagram therefore *visualizes* objects or processes in a way that matches them structurally, *emphasizes* elements deemed most important for comprehending those objects or processes, and *abstracts* or generalizes those elements such that they depict not the particular elements but the researcher's theoretical understanding of them.

An animation depicting, for example, how antibodies bind to antigens works similarly (see Figure 1). Even if the figures are abstracted to very simple shapes, such as Y shapes for antibodies and O shapes for antigens, their structure and the spatial relations between the two illustrate the scientific understanding of the objects and process.[8] The way the elements are drawn—such as the isomorphic match between the antigen as "ball" and the antibody as "cup"—emphasizes binding as the key feature of the process. But the details of that binding process are left out. The animation is not (nor is it meant to be) a 100 percent accurate rendering of what we would *see* if we could view such things; instead, the animation is a 100 percent accurate rendering of what we presently *theorize* about how such mechanisms work.

Yet the animation also moves, providing epistemic value beyond what a diagram can offer. Specifically, the animation depicts how the process works and how the elements move in relation to one another; it offers the spectator an understanding of the process in time and space. It therefore provides, sim-

7 Perini, "Diagrams in Biology," 275–276.

8 Wellcome Trust, "Animation: Developing Immunological Memory," January 8, 2015, YouTube video, https://youtu.be/SSYOVbEQj_4.

ilarly to a model, an *experiential* understanding of the objects and processes.[9] Like a model, an animation presents a theoretical space, akin to a fictional world, for the researcher or the viewer to explore.[10] While scientific models and animations may or may not come with narratives, they, like fictional worlds, come with conventions—specifically, conventions of drawing, design, and movement to help depict the objects and processes in time and space. Indeed, some animations, such as XVIVO and BioVision's *The Inner Life of the Cell* (2006), adopt conventions of commercial animation to convey their ideas about natural phenomena.[11] Likewise, studio animation and special effects houses adopt conventions or techniques from scientific animation for their fictional worlds.[12]

Researchers use models (and animations) to test the limits of their experiential understanding of these processes; if they can manipulate the environment by changing variables, then this understanding becomes *experimental* as well. Recently, advances in computer memory storage, processing power, fluorescence microscopy, and gene-mapping techniques have allowed scientists to mark and track cells; they can now capture these cells digitally, rebuild a cell population in a computer animation program, and apply algorithms to make that population "grow" according to the scientists' design.[13] The Allen Institute for Cell Science in Seattle, for example, uses these techniques and others to develop predictive computer-animated models that give answers to "What if?" questions any researcher might pose of the cell environment.[14] These simulations allow researchers to explore cell morphologies and locations in ways that only animation allows, giving scientists both experiential and experimental insight into cell function.

The Allen Institute for Cell Science is unusual in that team science—science practiced by interdisciplinary scholars working under one roof on a common project—is so integral to its mission.[15] Unlike interdisciplinary collaboration, which is common but sporadic, team science is steady in its exchange of expertise. In addition to the variety of scientific disciplines represented on the team, the sophistication and amount of animation

9 See Oliver Gaycken, "'A Living, Developing Egg Is Present before You': Animation, Scientific Visualization, Modeling," in *Animating Film Theory*, ed. Karen Beckman (Durham, NC: Duke University Press, 2014), 68–81.

10 See Gabriele Contessa, ed., "The Ontology of Scientific Models," special issue, *Synthese* 172, no. 2 (January 2010), especially the contributions by Contessa, Roman Frigg, and Adam Toon.

11 See Scott Curtis and Robert Lue, "Bridging Science, Art, and the History of Visualization: A Dialogue between Scott Curtis and Robert Lue," *Discourse* 37, no. 3 (Fall 2015): 193–206.

12 See Christopher Kelty and Hannah Landecker, "A Theory of Animation: Cells, L-systems, and Film," *Grey Room* 17 (Fall 2004): 30–63.

13 See, for example, Khaled Khairy and Philipp J. Keller, "Reconstructing Embryonic Development," *Genesis* 49, no. 7 (2011): 488–513; and Janina Wellmann, "Animating Embryos: The *in toto* Representation of Life," *British Journal for the History of Science* 50, no. 3 (September 2017): 521–535.

14 Allen Institute for Cell Science, "3D Probabilistic Modeling," Allen Cell Explorer, accessed December 20, 2020, https://www.allencell.org/3d-probabilistic-modeling.html.

15 See Rachel Tompa, Susanne M. Rafelski, and Graham Johnson, "'Not Just a Cog': A Q&A on Team Science in Cell Biology," *ASCB Science News*, May 7, 2020, https://www.ascb.org/science-news/not-just-a-cog-a-qa-on-team-science-in-cell-biology/.

hardware and software at the Allen Institute also imply a craft component; certain members of the team, whether animation specialists or scientists now expert in animation, must be very good at computer animation. In fact, the history of animation in science demonstrates that teamwork has always been common; in most cases, researchers sought out animators to help visualize their findings and ideas. Historiographically speaking, then, we should favor a *prosopographical* approach to animation and science by focusing on the teams formed around specific projects.[16] The collaboration of animators and scientists leads us to three areas of historiographical emphasis: *iconography*, *infrastructure*, and *influence*.[17]

The conventions adopted by the team are sometimes extremely common—the use of shading to signal depth, for example—but others can be traced to *iconography* in scientific illustration, animation, or other graphic traditions, including poster design, print cartoons, and informational graphics. For example, the use of a skeleton as a symbol of tuberculosis in the public health animations supervised by Jean Comandon in France after World War I drew upon a trope that had spread throughout France and Europe in posters, editorials, and public health literature about the disease. More recently, the use of animated "fly-throughs" in 3D CGI animations such as *The Inner Life of the Cell* recalls similar techniques in Hollywood productions such as *Fight Club* (David Fincher, 1999), which in turn echo scientific visualizations such as the Visible Human Project (1994). Examining these conventions is not about finding the origins of a trope, however; it is about uncovering the life of an image, how an image is made from a web of intermedial relationships. The use of conventions reveals scientific and artistic presumptions about the object of study and how those presumptions depend on a chain of images. Tracing this chain involves stylistic and serial analysis of those images.[18]

This chain of images extends not just backward in time but also across media in what Bruno Latour has called a "cascade" of successive images generated in the process of arriving at the final—or at least most recent—visualization.[19] Sketches, storyboards, and pencil tests in animation correspond to the rough work that researchers also carry out to visualize their data. To understand how any given visualization articulates an understanding of the phenomenon, we need to look at all stages of image production (or at least as many as we can access). This requires an understanding of the material and conceptual *infrastructure* of the production, from the space of the lab or studio to the technology and software to the disciplinary way of

16 Hentschel, *Visual Cultures*, provides a book-length discussion of what this approach would mean for histories of images in science.

17 This trilogy is the focus of a collaboration on "useful animation" between Malcolm Cook, Michael Cowan, and Scott Curtis. See "Useful Animation in Early Cinema," Domitor 2020, November 18, 2020, https://domitor2020.org/en-ca/roundtable-no-1-useful-animation-in-early-cinema/.

18 A good example is Kirsten Ostherr, "Animating Informatics: Scientific Discovery through Documentary Film," in *A Companion to Contemporary Documentary Film*, ed. Alexandra Juhasz and Alisa Lebow (West Sussex, UK: Wiley-Blackwell, 2015), 280–297.

19 Bruno Latour, "Drawing Things Together," in *Representation in Scientific Practice*, ed. Michael Lynch and Steve Woolgar (Cambridge, MA: MIT Press, 1990), 40.

seeing that each expert brings. The history of animation and science demonstrates that there is often a productive friction between these two ways of seeing as members of the team learn from one another. This transmission of knowledge is the most obvious evidence of mutual *influence* as the animator learns about the scientific data and theory while the researcher learns about the material limits and possibilities of the medium. The result is a collaborative vision of the phenomenon that expresses this collective understanding, which is eventually distributed to larger publics through journals, textbooks, science journalism, and other sources, all of which help to shape our everyday understanding of elements of the natural world.

Animation, therefore, has distinct advantages for scientific inquiry, as it uniquely combines functions and iconography from a variety of traditions, including modeling, illustration, simulation, and even cartoon history. This range of practices and conventions presents a daunting set of challenges for media historians. We must unravel the knotty entanglement of iconographic and production traditions, research agendas and laboratory protocols, disciplinary ways of seeing, and the specific formal features of the animated image. The investigation of animation in scientific fields provides an excellent opportunity to uncover the mutual influence of medium, discipline, and craft, which is the goal of this media history of science.

Yet the most compelling reason for cinema and media scholars to invest in this conjunction—besides the fact that our media landscape is simply rife with scientific images—is the impact animation has on scientific ways of seeing and thinking. Just as a researcher's pencil sketches dialectically inform and expand their understanding of the process under study, so animation has catalyzed how researchers conceptualize their object, especially in that computer animation provides ways of thinking beyond static two-dimensional models. Philosophical, sociological, and historiographical approaches to the use of animation in science can therefore help us demonstrate the influence animation has on their—and our—understanding of the natural world. The stakes could not be higher.

Scott Curtis is an associate professor in the Department of Radio/Television/Film at Northwestern University and the Communication Program at Northwestern University in Qatar. He is the author of *The Shape of Spectatorship: Art, Science, and Early Cinema in Germany* (Columbia University Press, 2015) and editor of *Animation* (Rutgers University Press, 2019).