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BOOK REVIEW

Philip Ball, *Beautiful Experiments: An Illustrated History of Experimental Science*

Chicago: University of Chicago, 2023. Pp. 240. ISBN 978-0-226-82582-3. $35.00 (cloth).

Gino Elia

Stony Brook University

Philip Ball's *Beautiful Experiments: An Illustrated History of Experimental Science* joins a body of literature aiming to establish the importance of experimentation in the history of science, such as Ian Hacking's *Representing and Intervening* (1983), Allan Franklin's *The Neglect of Experiment* (1986), Robert Crease's *The Prism and the Pendulum* (2004) and Lorraine Daston and Peter Galison's *Objectivity* (2007). Crease, Hacking, Daston and Galison are directly engaged with philosophy of science, while Franklin's histories give technical descriptions of specific experiments. Ball takes inspiration from both philosophy and history while remaining accessible to a general audience. *Beautiful Experiments* gives impressive descriptions of sixty experiments from physics, chemistry and biology. Each summary is succinct, but packed with intimate, rich historical details about the scientists and their equipment.

Ball includes historical photographs and illustrations of scientists, diagrams and the equipment used in the experiments. He also comments on the aesthetic value of scientific instruments, from their aptness for making a particular measurement to their elegant, ornate design. Ball notes that even though modern instruments look impersonal, sober, and sleek compared to pre-industrial-era tools, this may reflect a difference in aesthetic taste rather than modern professionals being more inherently 'utilitarian' than scientists in the seventeenth century. The motif of beauty in science reoccurs throughout the book in other ways, ranging from the persuasiveness of an experiment to the inventive use of existing tools for settling controversial questions.

Ball organizes experiments under broad questions like 'What is life?' and 'What is the world made from?' I was initially sceptical of this choice because I thought a chronological account might give a better sense of how far experimental science has evolved, such as the development of detectors from cloud chambers to particle accelerators. However, this was partly Ball's objective: to disrupt the narrative flow of idealized history and return experimental science to messy ingenuity and the art of practising with untested tools. Given the diversity of themes, readers looking for a decisive account of what an experiment really is will not find one. Ball avoids feeding readers easy conclusions about experiments or their value for knowledge. He ends the book with the stimulating words, 'You should not suppose there is any consensus today on what "experiment" means!' (p. 236). This reflects the originality of Ball's approach, since Hacking, Crease, Franklin and perhaps Daston and Galison attempt to state the 'meaning' of experiment in different and sometimes diverging ways.

The role of equipment was, for me, the most fascinating theme of the book. Many experiments illustrate how a scientific instrument embodies concepts of a physical system in its design. In other words, scientists do not collect evidence simply by affixing tools to nature. Rather, the invention of new instruments tends to presuppose a rough notion of what evidence we are supposed to find. For instance, the suspicion that air could be pumped out of a sealed container led to the invention of vacuum chambers. Theory tends to motivate experimental design, but experimentation is not just a confirmation check for theories. New equipment functions as a site of exploration, a controlled playground where new phenomena are revealed 'theory-free' (p. 46). Equipment creates a specialized window for posing questions to nature. As physicist Gerd Binnig says of the tunnelling microscope, 'it was [like] entering a new world' (p. 118). Our instruments do not simply record nature; they make nature recordable. Ball's descriptions of equipment constantly highlight the interplay of theory and experiment, showing how difficult it is to tell where one ends and the other begins.

At first, *Beautiful Experiments* comes across as a reference book of cool experiments, but it quietly subverts that impression. Ball raises important concerns about elitism and black-boxed knowledge in science. The sale of specialized, handcrafted instruments in the seventeenth and eighteenth centuries became an expensive hobby for socialites. However, the expense and skill needed for scientific instrumentation create problems for replication. Who can afford a particle accelerator to double-check the existence of the Higgs boson? When thousands of scientists and years of planning are needed to test the existence of gravitational waves, does this mean that the improvisation of idiosyncratic scientists is nearing an end? Such massive collaborative projects, Ball notes, are at risk of herding into groupthink where individual creativity is suppressed. Discussing the Millikan oil drop experiment, Ball points out that replication sometimes requires the guidance of the scientists who conducted the original experiment. If the trained judgement of past practitioners is required to redo a test, is it really replication?

My main critique of *Beautiful Experiments* is that its best ideas are latent. Sometimes significant themes seem buried amidst historical discussion. I would not be surprised if some of Ball's commentary is overlooked. Despite the importance of these conversations, Ball often raises essential questions only to drop them in the same paragraph. The discussion of groupthink in his section on gravitational waves never resurfaces, despite its far-reaching implications.

Ball compensates for his curtness with introductions to philosophy of science in sections called 'interludes'. To some, these breaks between the discussions of experiments might seem inessential. However, the interludes act as a sort of conceptual backbone for the rest of the book. Ball's philosophical goals are not wholly independent of the way he conveys its history. In fact, many of Ball's experiments have something akin to a 'moral', like how the fictional substance 'phlogiston' at least gave scientists a workable framework for debating combustion and respiration. Another example is false definitiveness. Physics textbooks tend to portray the Michelson–Morley experiment as a demonstrative refutation of the ether, but it was seen as a null result until it was reinterpreted in light of Einstein's work.

Beautiful Experiments offers a surplus of vital experiments for researchers needing thematized examples for book writing and is ideal for classroom instruction. I wish Ball had included a references section, not just an index. For historians looking to delve into a specific experiment, Ball's source material is not readily citable.

One of the stubborn misconceptions about the history of science is the view that science progresses through a linear series of eureka discoveries made by solitary geniuses, who are, as Ball remarks, typically 'Western and male' (p. 236). As Allan Franklin wrote in *The Neglect of Experiment*, when we historicize science through a handful of key

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characters and paradigmatic experiments, those experiments can attain an almost mythic quality in retrospect. *Beautiful Experiments* tells a different story about the beauty, ingenuity and messiness of experimenting, where knowledge coalesces into something better than before. Such an account is more intellectually honest, and ultimately more satisfying.

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