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Catherine Wilson. *The Invisible World: Early Modern Philosophy and the Invention of the Microscope.* Princeton, N.J.: Princeton University Press, 1995. x + 280 pp. $35.00 (cloth), ISBN 978-0-691-03418-8.

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All knowledge is generated within particular horizons of concern out of which meaningful questions emerge about the data circumscribed by the horizon that drive the question-answer-question cycle of inquiry forward. Such horizons of inquiry are taken for granted, little thought about, until new data or evidence raises new questions that cannot be addressed within the horizon, but which require a substantial revision of horizons. New questions expand old horizons, until stretched to the limit, the old horizon is replaced with a new one better able to drive the cycle of questions and answers forward. This engaging book by Catherine Wilson provides an exceptionally good narrative of just such a process in which new data raises new questions and new questions raise even deeper questions about the adequacy of interpretative horizons.

Wilson's study is an analytical account how the invention of the microscope in the seventeenth century opened up a new world of observation. This event profoundly revised the thinking of scientists and philosophers by widening the empirical horizon to a subvisible world (p. 252). However, as she shows, the data observed in the expanded new empirical horizon did not readily "fit" the existing explanatory forms based on geometry, astronomy, and mechanical physics. Yet the knowledge generated by microscopy was real (p. 254). Its reality imposed an obligation to explain.

This need to explain what was seen and to account for its relation to world process gave raise to the key problematic facing microscopic scientists: in what sense did the subvisible images produced by the microscope explain anything. That is, what was the meaning of these images and how did they relate meaningful to what was known?

In describing how early microscopist addressed these questions, Wilson raises an interesting question for historians, scientists and philosopher: how did developing methods of seventeenth-century microscopy contribute to the development of modern science? Wilson argues there are three broad areas. First, the microscope put into question that type of explanation that required broad appeal to form and final causes. Second, the microscope substituted subvisible textures and motions for occult powers, dispositions, and capacities and so gave meaning to the notion of the interpretation of nature that corpuscular (Descartes, Leibnitz) or mathematical (Galileo, Newton) philosophy had been unable to supply. Third, microscopal observation gave promise of a view of the world based in experience rather than abstract thinking or intellection. Each of these contributed to what Wilson argues is the essence of modern science that emerged from protoscience and by extension has become constitutive of the modern mind. I will return to these conclusions later. Let me try to outline her argument.

The subvisible world was literally a "new world" that came into view with the invention of the microscope. The "new view" required a new framework of interpretation. This reality, the givenness of the subvisible data, presented major methodological challenges to scientists and ontological and epistemological problems to philosophers. The "interior of nature," once closed off to both intuitive reason and direct perception, was now accessible and factual. But the new facts were merely facts because there were no evident connections or meaningful relations among the facts or between the new facts and the accepted patterns of relating the old facts. Reconsideration of this event, Wilson argues, invites a shift in the explanation of the arrival of modern science from one grounded all but exclusively on the geometry of remote celestial science to accord a place to "scrapings, bodily fluids, bits of earth, and fragments of tissue" of the proximate subvisible world.

Wilson brings formidable evidence and analytical skills to support her thesis. If she is correct, it forces a substantial reconsideration of the history of science that ignores the contribution of the biological sciences to the Scientific Revolution whose cover story now accords exclusive preeminence to the abstract sciences. As well,

there are features of her argument requires some reinterpretation of the epistemic concerns of early modern philosophy. In essence Wilson argues that the microscope led to a conception of science as an objective procedure-driven mode of inquiry based on observation and experiment rather than one based on abstraction, mathematics and deduction. The epistemological explanations of both rationalists and empiricists failed to a significant degree to provide a comprehensive and intelligible explanation of the new phenomena the microscope made available. Thus, the inquiry about the subvisible world went forward not because it had an adequate methodological foundation, but because the method as a practice yielded usable knowledge and knowledge generating questions. Without ignoring the important philosophical discussions of Aristotlean science in early modern philosophers, Wilson manages to shift the ground of the discussion from philosophy in itself to method and meaning. Wilson's presentation is divided into eight chapters. Chapter one considers basic, yet important methodological issues about the periodization, description, and evaluation of the 17th century Scientific Revolution. Chapter two deals with the knowledge of the occult as both what is hidden and what is superrational. Here she argues that what is important about the microscope is that it undermined confidence in the "manifest image" of the world. Even as it undermined what was clearly and distinctly visible, the microscope supplied a "latent image" that gave a glimpse of a nonoccult interpretation of nature. Chapter three covers the history of the microscope and opens the epistemological problems of instrument-based knowledge. Chapters four and five discuss microscope-based theories of generation, contagion and disease. The microworld and the apparent role of living animalcula in generation, contagion and disease presented significant problems to philosophers concerned with essences, substances, qualities and the limits of human knowledge.

Theories about the microworld were supported only by circumstantial and not direct evidence raising the problem of the relationship of experience and intelligibility in a new way. Chapters six and seven document the existential, ontological, epistemic, and theological 'dislocation' induced by the discovery of the microworld. Chapter six argues that philosophers tried to turn the empirical result of the microscopical science to support metaphysics and theology. In chapter seven she reverses direction and argues that the controversies between empiricists and rationalists were responses to increasing experience with the views opened up by the microscope. Chapter eight gathers up the strands of her complex arguments to support her thesis that the sudden movement outward of the perceptual horizon could not be (and was not) a matter of indifference. There is very little question that Wilson is correct, but what is in issue is whether her interpretation of the importance and contribution of the event will stand critical scrutiny.

First, Wilson wants to provide grounds for a revision of the "cover story" of the Scientific Revolution, by arguing that microscopy, even in its infancy, supplied an observational experimental method that is important for the emergence of modern science from protoscience and constitutive of the modern intellect. Wilson successfully argues that the subvisible world revealed by the microscope required integration into the notion of perception (a familiar commerce that had to be negotiated in its infancy out of ambiguity and confusion, p. 256). However, there is still something to be said for the "cover story." I would argue that we must understand that the early modern fascination with the abstract methods of physics had as much to do with the discovery of meaningful measurement and quantification as geometric deduction. Part of the delay in the development of microscopic science and biology was directly due to the problems of measurement and quanitification in these fields. This is a problem Wilson documents very well (pp. 90-91). She does not, however, consider its significance in relation to her proposed revision of the cover story of the Scientific Revolution.

Here the issue is one of understanding what was at stake in early modern science. Galileo and others wanted an absolute. The absolute is not expressed in particulars but by invariant expressions, a description of intelligible relations, for which particulars provide a ground. Thus what is known absolutely is known by formulating and verifying invariant principles and laws. However, as long as we are speaking of particular things, we cannot avoid employing relative expressions. Measurement and quantification appear to escape the relativism of the particular, because numbers substitute for the sensibly particular. Through measurement early scientists were able to turn from the relations of sensible terms, which are correlative to the senses, to the relations of numbers and quantities, which are correlative to one another. Such is the fundamental significance of measurement. The subvisible world of the microscope, however, was not measurable or consistently quantifiable. Therefore, its results were always in doubt (uncertain). To be sure, as Wilson points out, learned societies could insist on experimental replication, but the replication was always a replication of particular sensory data and the move from description to explanation, from the particular to the general appeared blocked by the problem of measurement. And without the move from the particular to the general,

from data to concept and proposition, the revision of deduction, there was no adequate explanation. Without the revision made possible by deduction there was no scientific advance because the advance of science is a circuit, from data to inquiry, from inquiry to insight, from insight to the formulation of premises and deduction from their implications, from such formulation to material operations, which yield fresh data and, in the limit, generate the new set of insights of higher viewpoints. A basic revision in science, then, is a leap. At a stroke it is a grasp of the insufficiency of both the old laws and of the old standards. At a stoke, it generates both new laws and new standards. Finally by the same verification, it establishes that both the new laws and the new standards satisfy the data. Wilson shows that the microscope provided new data and new questions, but she does not show that new standards and laws emerged from the dislocation brought about by the subvisible world. This is what is required if we are to accept her revised thesis concerning the catalyst of the Scientific Revolution.

Second, Wilson's arguments about the historical trajectory of early modern philosophy and the empiricist-rationalist debates is based on a thin sampling of texts. The texts she chooses to use are well used. She does not impose on the texts but neither does she link the texts to their contexts and so leaves the impression that preoccupation with subvisible phenomena was more widespread than perhaps it was.

What is fascinating about this book is the way Wilson shows, albeit indirectly, the extent to which the cognitional myth that knowing is like taking a look was a driving forward the epistemological debates of early modern philosophy in dialogue with the new knowledge generated by the methods and procedures of science. Science generated knowledge not by hitting on the right ontology or epistemology, but by following a procedural method of observing and explaining (pp. 243-44).

This debate, which continues to be echoed in disagreements between realists and social constructionists and empiricists, idealist and realist, forces us to reconsider what we mean by method (p. 101) and its relation to what exists. Wilson argues that method is neither a path to the truth nor a set of rules that prescribe what truth is. Method is only a help to the generation of descriptions that would not otherwise be produced, and whose acceptance depends upon factors other than how they were generated. Allowing Wilson her position, one wonders what the cognitive content of method is if Wilson is correct. Method appears by her account to simply be a pattern through which data is grasped, a means of observing, recording, and relating. But does method not include understanding, judging, and deliberating about what one has judged. That is, isn't the trajectory of modern science on of moving from description to explanation and verification of explanations rather than in "training the eye" and mere observation? Objectivity is not in the eye or its instrumental extensions, it is in the subject who poses questions and seeks answers to those questions.

Wilson argues, however, for the "eye" and observation. To do so she pilots a position between realism and constructivism arguing that theories do not represent, do not correspond to reality; and yet "it is true there is a reality beyond our representations" whose weight and push determine appearances for us" (p. 256). Wilson falls into the same epistemological trap that she argues the observational science of early microscopy overcame in practice. Though one would suspect from Wilson's position that she does not regard this as a trap but simply the limitation within which all knowledge is produced and which, over the long term, accurate observation and experimental procedures overcome as we "extract meaning from the optically indeterminate" (p. 256). The question is then whether her reconstruction of this important period is a reflection of her view of what science is rather than what went forward in history through the Scientific Revolution. I suspect it is the former rather than the later and one must weigh her argument accordingly. However, this does not minimize the significance of Wilson's contribution to our understanding of a pivotal period in Western culture.

This is a book to be read and taken seriously. It is a serious book about an important period of intellectual history. Given the complexity of the task that Wilson carves out for herself, the book requires a great deal of effort to read though, because of the very careful use of data. There are times, however, when the data overwhelms the argument making the argument difficult to follow. Wilson doesn't help because she gives no map to it. One must wade through the facts to the meaning of the facts in relation to the argument.

This is a book of interest primarily to scholars and advanced graduate students in the philosophy and the history of science.

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