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BOOK REVIEW

Anne Marcovich and Terry Shinn, *Toward a New Dimension: Exploring the Nanoscale*

Oxford University Press, Oxford, 2014

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As its title hints, the analytical approach of this book maps neatly onto the subject area that it addresses. It is oriented toward the fine structure of scientific research in the microscopic domain. The coverage deals with what the authors describe as investigation of the roles of instrumentation and materials in shaping research at the nanoscale, and epistemological questions relating to 'form, image, descriptivism and determinism' (p.1). In so doing, the authors distinguish their work from other themes of recent and contemporary interest, including science policy, the public understanding of science, and its role in post-modern culture.

Toward a New Dimension: Exploring the Nanoscale argues that, in both form and practice, nanoscale research has characteristics unlike earlier scientific fields. The study consequently suggests continuities and discontinuities with earlier histories, sociologies and philosophies of science. Alternative framings are at the heart of the examination: is nanoscale research a discipline in the making, interdisciplinary, or something else? How do its evolving practices conform to, or deviate from, prior methods of knowledge production?

Drawing on research founded on a combination of analyses of published texts and interviews with scientific practitioners of the art, Anne Marcovich and Terry Shinn provide both a guided tour through, and sojourn in the niches of, the new science. Along the way, they offer organising insights and neologisms to identify particularities and categories suggestive of general features. The domain illustrates attributes relating to the creation and circulation of knowledge that may be indicative of other emerging specialisms.

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In a field dominated by innovative and uniquely powerful variants of experimental techniques, acronyms are frequent. The authors label their subject nanoscale research (NSR), and indeed the prefix *nano* has become ubiquitous as a qualifier of practices, practitioners and their domains. The field relies on a jostling assortment of technologies for molecular-scale exploration and manipulation, including Atomic Force Microscopy (AFM), Scanning Tunnelling Microscopy (STM), Scanning Probe Microscopy (SPM), Molecular Beam Epitaxy (MBE) and Self-Assembling Monolayers (SAM). The metrological scale is less detailed than the resolution provided by earlier techniques such as Transmission Electron Microscopy (TEM) but, by contrast, allows non-destructive examination and fabrication of individual atomic and molecular elements. The first chapter leads the reader across this confusing terrain described by some observers as 'totally fragmented, where each specialty possesses its specific nano routines' (p. ix).

The nanoscale certainly evinces unusual attributes that encourage new forms of scientific investigation. Physics from the mid-nineteenth century had grappled with the microscopic scale in the form of ensemble averages – statistical insights about the behaviour of large numbers of particles; early twentieth-century quantum mechanics had encouraged the acceptance of an inevitable uncertainty of experimental detail at the atomic scale. By contrast, however, nanoscale techniques can map the positions of individual atoms in solids to reveal crystal structures and molecular morphology. Epitaxial techniques can assemble atomic structures and compounds by design, transforming experimentation into practices more akin to engineering prototyping and testing.

As a result, note the authors, experimental practices have shifted towards 'descriptivism'. When individual molecules can be detected and positioned, nanoscale understandings are direct rather than inferred. Researchers' working understandings benefit from this new local precision. Concepts become concrete ('deterministic') when varying potentials and forces can be translated into pictures via computer-assisted imaging. This seductive visualisation can misrepresent, however, in ways that the older stochastic methods of microphysics did not.

The field of study also encourages new forms of experimental team. The nanoscale microscopists increasingly study structures created by 'epitaxiors', or atomic-scale fabricators. Their results are predicted, modelled and tested by colleagues employing computer simulation models. These three scientific activities – detecting/measuring, constructing and modelling – have routinely and copiously co-produced knowledge and products over the past thirty years. The authors refer to the novel combination of two disparate techniques as a 'combinatorial', and dedicate a chapter to exploring how such unions provide fertile new powers. The inter-dependence of metrologists, synthesizers and simulators, referred to as a new variety of alliance that the authors dub 'research by design' (p.10) may sound rather like the traditional interactions of mixed teams of scientists and technicians/technologists in experimental research, particularly in domains at the interface between academic science and engineering. Marcovich and Shinn argue, however, that the pace and interactions are different in kind. First, visualisation accelerates researchers' insights in ways that graphs and tables did not. And second, the eclectic possibilities enable frequent reconfigurations of experiments and teams. The authors' term 'respiration' describes how researchers pause to 'take a breath during which [they] take stock of what new combinatorials are available for development of their present research project, or alternatively, that can be mobilized for initiation of a new project' (p.11). This periodic reflection and reintegration encourages a resumption of research impetus with new resources or a shift in research direction with new collaborators or research questions.

Nanoscale research – at least while it remains a relatively young field in an exploratory phase – has another peculiarity: '[t]heory as abstraction, integration, and generalization is by and large absent' (p. 193). Empiricism is not merely highlighted: description is the central activity. This is exploratory science reminiscent of Galileo's exploration of the surface of the moon with his telescope. The authors cite key contributors who built careers on their curiosities to examine a wide variety of materials to see how they looked, and others who explored and expanded the new techniques exhaustively to characterise and, eventually, to conceive and synthesize new materials. In the process, this serial experimental activity appears to have exhibited the qualities vaunted by nineteenth-century positivists: acquiring discrete nuggets of information, building them into more general categories of description, and co-developing the experimental techniques to progressively extend their grasp and vision.

Perhaps the richest vein in the book is its speculation in the final chapter on the disciplinary or interdisciplinary nature of the new field. Combinatorials generate new mergers of knowledge such as simulation-verified metrology, and 'chemo-mechanics' (p.183). These novel subject competencies are cross-borderland projects defined by boundaries, incursions and safe territories; indeed, the terminology is evocative of post-911 sensibilities.

While identifying nanoscale research as a young field for which 'time will tell' (p.190), Marcovich and Shinn devote the book's last chapter to suggesting that the subject is as an example of a variant kind of disciplinarity they dub the 'new disciplinarity', and which they characterise formally as having a number of identifying traits. In the new disciplinarity exemplified by NSR, researchers inhabit their 'homeland' discipline, while 'shouting across the boundary wall' (p.ix) to colleagues in other disciplines. Successful NSR researchers inhabit the borderlands for much of their collaborative work, adopting 'an outward-looking gaze', but generally returning to the heart of their disciplines between projects, retaining their 'intellectual and institutional coloration' (p.173). The authors suggest a cyclical, short-term displacement to the borderlands (an example of the respiration mentioned above) to pursue particular projects, but an inevitable return to the heartland of the researchers' disciplines for a foundational referent. They argue that this displacement and temporality distinguish new disciplinarity from other forms.

As a contribution to a growing body of scholarship, this volume usefully refines important sociological and epistemological concepts in light of the unusual contemporary characteristics of nano-fields. It will be valuable as a model for better understanding the internal dynamics of new sciences.

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