Stephen Gaukroger
The Collapse of Mechanism and the Rise of Sensibility: Science and the Shaping of Modernity, 1680 -1760.
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This massive study is the second in a projected five-volume series that began with the equally imposing *Emergence of a Scientific Culture* (Oxford University Press 2006). Where *Emergence* is concerned with the rise and influence of the mechanical philosophy in the seventeenth century, *Collapse* is concerned with its decline and usurpation in the first half of the eighteenth century. Like its predecessor, *Collapse* covers an immense range of pertinent issues, from Newton's geometrical approach to the calculus, to the epistemology of the French *Encylopedists,* to the re-conception of historiography in the Enlightenment. Some approaching the volume with a particular research agenda (e.g., British empiricist meta-ethics) might safely skip certain chapters (e.g., Chapter 2, on Newton's *Principia*). Nevertheless, the volume as whole is sustained by several illuminating and plausible unifying themes, such as the relaxing of the methodological demands for 'picturability' and demonstration, the re-admission of inherent activity into nature, and the increasing disunity of the sciences. Moreover, Gaukroger's exposition is exceptionally clear, sober and thoughtful, if sometimes exhaustingly thorough. The astounding wealth of up-to-date primary and secondary sources in the footnotes and bibliography would be valuable even if Gaukroger's own analysis of the collapse of mechanism were weird or banal. In fact, it is consistently compelling and rich.

Collapse has five untitled parts each with two or three long chapters. Part 1 sets out the ambitions of the mechanical philosophy of Descartes, Gassendi and Huygens to supplant the Christianized Aristotelianism of the scholastics. Since the new philosophy aspired to reduce all natural phenomena to the motions and collisions of geometrically characterized bodies, matter theory was of crucial importance. Metaphysics, the traditional science of the most abstract categories, i.e. 'being qua being', was re-assigned the specific task of validating the geometrical conception of matter and other principles of natural philosophy. Thus the Cartesian priest-philosopher Malebranche would define metaphysics as 'the general truths that can serve as the principles of the emerging sciences' (29). Theology, too, was transformed by the rise of the mechanical philosophy. For radicals, like Spinoza, religion was restricted to the provision of moral guidance. For more orthodox theists, like Malebranche, the new science revealed the absolute dependence of the world on God and, through its mathematical structure, provided a window into the very mind of God. In turn-of-the-century England, as the natural theology of Bacon and Boyle became wedded to the Newtonian program, a host of 'physico-theologies' were formulated to reconcile, or mutually validate, Newtonian laws and divine providence. Newton himself employed God in Query 31 of his *Opticks* to prevent the solar system from collapsing and to ground absolute space (God's 'sensorium'). Leibniz complained about this use, or abuse, of God in the famous correspondence with Clarke, though Gaukroger points out that Leibniz (along with

Burnet and many others) shared the goal of 'rationalizing' religion by linking it to the new philosophy. In the moral domain, a similar effort was underway to secure the traditional connection between God and law.

But the guiding assumptions of the mechanical philosophy were soon called into question. Shortly after the publication of Newton's *Principia* (1687) Leibniz proposed that gravitational attraction must be mediated by a material ether, on pain of admitting action-at-a-distance. This question whether the force of gravity required a medium or mechanism, which bothered Newton himself, ultimately signaled the transition from strict Cartesianism to the 'rational mechanics' of the mid-eighteenth century. The stage for this transition was set by Newton in the *Principia*. As Gaukroger skillfully explains in the second chapter of Part 1, Newton's intention in the *Principia* was to replace Cartesian mechanism, especially its vortices, with a thoroughly mathematical dynamics and kinematics that mostly sidesteps traditional matter theory. The remainder of *Collapse* explores the transformation of natural philosophy, and the broader intellectual culture, in the wake of Newton's triumph over Descartes.

The first two chapters of Part 2 examine the roles of Leibniz and Locke, respectively, in this transformation. Leibniz proposed metaphysical foundations for natural philosophy which did not rely on the geometrical or 'picturable' conception of body. Rather, bodies are fundamentally point-like centers of force or activity. This allowed him to account for various dynamical effects better than Descartes though, as Gaukroger notes, it also pushed the mechanics of ordinary gross bodies 'into the phenomenal realm' (117). This highly abstract approach to natural philosophy mirrors Leibniz's preference for an algebraic version of the calculus (as opposed to the geometrical 'fluxions' favored by Newton). Although Leibniz's mechanics made no headway, his algebraic approach to natural philosophy was enthusiastically adapted to the 'rational' or 'analytical' mechanics of Continental Newtonians like d'Alembert and Lagrange. Meanwhile Locke, despite his admiration for the 'incomparable' Mr. Newton, called for epistemic modesty about scientific hypotheses going beyond immediate experience, including the corpuscularian models of his friend Boyle. Locke also clung to the geometrical ideal of scientific demonstration, which led him to despair of a 'perfect Science of natural bodies' (151). Gaukroger provides a highly interesting, philosophically subtle account of the development of Locke's empiricism and its enormous influence on subsequent generations of natural philosophy in England and France (where it was always affiliated with Newtonianism regardless of Locke's epistemic scruples). The final chapter of Part 2 details how Lockean empiricism promoted the autonomous development of botany, electrical theory, and chemistry, and concludes with a brief philosophical rumination on scientific explanation.

Part 3 shifts focus to the institutional setting of natural philosophy in France, especially the Académie des Sciences and the Republic of Letters. Gaukroger shows how not only competing ideals of the proper aims and methods of science, but even the ongoing debate over Cartesian vortices vs. Newtonian gravitation, influenced the direction of scientific institutions and consequently the place of science within the broader culture. The second chapter takes up the role of the *philosophes* and

encylopedists, especially Voltaire and Diderot, in the promulgation of their conception of the Newton/Locke worldview: deterministic, empiricist and liberal. This advocacy, Gaukroger argues, is one facet of a broader effort to elevate the 'cognitive values' of natural philosophy over those of the church and the court.

Part 4 returns to 'internal' examination of the collapse of mechanism in several scientific fields. To frame this examination, Gaukroger distinguishes between two alternatives to the mechanical philosophy's ideal of scientific explanation as reduction to a single, intelligible (hopefully picturable) model: i) assimilation of a broad class of phenomena to a narrower class at the same level (horizontal reduction); ii) reduction of macro phenomena to a smaller, but not necessarily ultimate, level (meso-reduction). He illustrates the first by the rational mechanics of d'Alembert and Euler, which derives explanations from *a priori* laws of inertia and collision. Gaukroger indicates that the justifications for the laws tend to be truly *a priori* only when they are circular. He illustrates the second alternative through several domains of 'matter theory', including electricity and fluid chemistry. Gray, Franklin and Geoffroy succeed in these fields not by forcing reduction to smaller and smaller corpuscles, but by isolating irreducible and seemingly non-mechanical processes at the 'meso' level: attraction, equilibrium, sympathy, and so on. Non-reductive approaches also flourished in biology, especially theories of generation, and in historical geography and anthropology, where Buffon identified non-mechanistic principles of development. With the success of non-reductive and pluralist explanatory strategies in these fields, the unity of natural philosophy itself came into question.

Part 5 depicts natural philosophy's shift to 'understanding of our place in the natural world' (389). Under the influence of Locke and his French disciples, 'sensibility' became a common rubric governing the complex interactions between humans and the environment in the sciences of psychology, medicine and ethics, which seemed intractable to strictly mechanical analysis. In physiology, inherent vitality or *anima*, even teleology, was reintroduced by Stahl, and the whole organ, rather than its corpuscles, became the fundamental explanatory concept: each organ cames to be regarded as an 'animal in animali' as Bordeu put it. (400) This made questions about the unity and identity of the human subject more pressing than ever. Morality, which travel and trade had revealed as culturally variable rather than innate or God-given, was conceived as a special kind of sensibility by Shaftesbury and Hutcheson. And developmental and naturalistic accounts of the 'history of manners', which heralded the arrival of natural philosophy, proliferated. The shift to sensibility in the analysis of human cognition also implied a turn away from pure reason, culminating in the Humean doctrine that reason is 'slave of the passions'. This was understood as an extension, rather than repudiation, of Newtonianism. Hume characterized his *Treatise of Human Nature* as 'an attempt to introduce the experimental Method of Reasoning into Moral Subjects' (438). As Gaukroger sees it, Hume's skepticism is a corrective to excessive rationalism: human understanding and flourishing require a balance of reason and sensibility. History and 'experimental' psychology should be our guides.

Especially considered together with the previous volume, *Collapse* is a remarkable achievement, comparable in ambition and execution to Jonathan Israel's series of volumes on the socio-political side of the Enlightenment. Gaukroger is especially to be thanked for his deft integration of mathematical, metaphysical, theological and empirical issues, which are routinely treated in isolation by commentators though they were never completely distinct in the minds of the most important actors. This is a model for serious intellectual history of science. Only three volumes to go…

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