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Marcus P. Adams • Zvi Biener • Uljana Feest
Jacqueline A. Sullivan
Editors

Eppur si muove: Doing History and Philosophy of Science with Peter Machamer

A Collection of Essays in Honor of Peter Machamer

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Editors
Marcus P. Adams
Department of Philosophy
University at Albany SUNY
Albany, NY, USA

Zvi Biener
Department of Philosophy
University of Cincinnati
Cincinnati, OH, USA

Uljana Feest
Institute of Philosophy
Leibniz University of Hannover
Hannover, Germany

Jacqueline A. Sullivan
Department of Philosophy, Rotman Institute of Philosophy
University of Western Ontario
London, ON, Canada

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Introduction

This volume celebrates Peter Machamer by collecting the work of scholars who, at one time or another, were his students. It is a testament to his intellectual reach, as well as his flexibility and influence as a mentor. All of us—though separated in age by decades and writing across a wide array of subjects and styles—continue to write with his grumbling voice echoing in the back of our minds. We still imagine our latest products returned to us (often within days) with barely legible (and often foul-mouthed) marginalia, pushing us to clarify, elaborate, and (in many cases) simply cut out that [expletive]. For this reason, the volume is subtitled "Doing History and Philosophy of Science with Peter Machamer." Even essays that do not directly engage with Machamer's publications bear the marks of his mentorship, a tough love that was both harsh and eminently supportive.

The volume's wide array of subjects and styles also highlights the flux and diversity of the field of history and philosophy of science and Machamer's role in some of its transformations. For this reason, the volume is titled (tongue-in-cheek) *Eppur si muove*, thereby acknowledging Machamer's work on Galileo, in particular, and alluding to the many ways in which he has moved the field, in general. Machamer has also stressed to us, his students, that *we* were responsible for moving the field. In fact, among his outstanding qualities as a teacher are his acute sensibility for novel and original topics and his willingness to take his students' untutored and sometime heterodox ideas seriously while continuously nudging them to do better and inserting at crucial moments his unique perspective into their projects. It is no coincidence that some of the most influential contributions to recent movements in philosophy of science—concerning mechanistic explanations, values, and inductive risk—were spearheaded by Machamer's students.

In the following, we offer a brief overview of Machamer's academic career and achievements, interspersed with a few observations about how his work has influenced his teaching style. We then offer some remarks about the individual papers collected in this volume.

Peter Machamer earned his earliest renown in the history of philosophy by taking to task Paul Feyerabend's account of Galileo. Feyerabend was then a celebrated, perhaps even revered, scholar, and Machamer a young PhD from the University of

Chicago. With what would become his trademark directness and discernment, Machamer dismantled Feyerabend's view of Galileo as a free-wheeling opportunist and offered instead an interpretation of Galileo as a careful observer and reasoner. Over the next few decades, Machamer continued to elaborate his picture of Galileo: Galileo attempted to explicate the world in terms of a physically intelligible and mathematically tractable mechanism—the balance. In doing so, he exploited elements of the Archimedean-influenced mixed-mathematical tradition, stressing the importance of causal reasoning and mathematical idealization, but returning always to the primary exemplar of the balance. Machamer's findings are now standard in Galileo scholarship. They are represented in his influential 1978 paper "Galileo and the Causes" and, more recently, in "Galileo's Machines, His Mathematics, and His Experiments," which appeared in *The Cambridge Companion to Galileo*, also edited by Machamer.

But Machamer has never been narrowly focused, as his engagement with the variety of trends in early modern science and philosophy clearly demonstrates. Recently, his *Descartes's Changing Mind*, coauthored with J. E. McGuire (Princeton University Press), made a splash among Descartes scholars. In it, Machamer and McGuire argue that Descartes's basic positions shifted dramatically during his life. With verve, they show that the assumption that "Cartesian Philosophy" means *The Meditations* is flawed and that we have much to learn from the evolution of Descartes's views. Importantly, they reveal that the mature Descartes holds an "epistemological stance" on which human knowledge is severely limited and granted, by God, for limited purposes. The impact of this view on the nature of rationalism and speculative philosophy has yet to be fully appreciated, but reviews of the book have been uniformly laudatory. Most repeat a motif often heard in regard to Machamer's work: that it is refreshingly penetrating, that it cuts through complex issues with a deft hand, and that it invigorates positions and debates that others have thought stale.

Machamer's work on Galileo, Descartes, and the mechanical philosophy more broadly is complemented by equally penetrating studies of Hobbes. Machamer has long argued that the consistency and unity of Hobbes's philosophy are underappreciated; indeed, Hobbes may be the most consistent seventeenth-century philosopher, and his system may be the period's most coherent. Machamer's approach to finding unity in Hobbes's philosophy has relied upon examining Hobbes's nominalism and exploiting it to see connections between Hobbes's accounts of language, natural philosophy, politics, and religion. He has recently edited a special issue of *Hobbes Studies* devoted to papers that explore these connections between Hobbes's natural philosophy and other areas.

Machamer's breadth in the history of philosophy is perhaps best exemplified by the wide range of historical dissertations he has supervised. These include works on Roger Bacon, Galileo, Gilbert, Harvey, Descartes, Hobbes, Spinoza, Euler, Auguste Comte, Freud, and Malinowski.

In addition, a word on Machamer's method is appropriate. Machamer is neither a philosopher's philosopher nor a historian's historian. His work does not rest in one methodological gully, blind to happenings in the larger intellectual landscape.

Rather, he has always been sensitive to various historical, philosophical, literary, sociological, and cultural concerns, as well as current developments in the sciences. His work allows conclusions from one area of study to influence others, thus weaving a narrative richer and more penetrating than those of more limited approaches. The ability to draw from unorthodox resources has been at the heart of his pioneering (and often controversial) positions—like those in, say, "Galileo and The Causes" and *Descartes's Changing Mind*. He has urged his students to do the same. For example, he urged students with systematic philosophical interests to consider the history of their subject matter and students with more historical interests to consider the contemporary philosophical implications of their views.

Thus, it is not surprising that Peter Machamer—in addition to supervising work on a truly impressive range of topics—has made important contributions not only to the history of early modern philosophy but also to several debates in contemporary philosophy of science concerning scientific knowledge and the nature of scientific explanation. These two topics are intimately related. A primary aim of science is to advance our understanding of the world by providing explanations. Yet, assessing whether a given scientific explanation truly advances our knowledge requires an understanding of, for example, how that explanation came about, what methods were employed in the process of discovery, and whether and how values and theoretical assumptions may have shaped this process. These questions, once again, highlight how Machamer views science as a complex human endeavor that is situated in multiple historical, social, material, and practical contexts.

Machamer's early work, including such articles as "Observation" (1970), "Recent Work on Perception" (1970), and "Understanding Scientific Change" (1975), exemplifies this point. It was a critical response to the logical positivists' distinction between theoretical and observational languages and as such was part of the general pushback against early twentieth-century philosophy of science in the wake of the works by Thomas Kuhn, Norwood Russell Hanson, and others. Insofar as Machamer brought findings from a variety of different areas of inquiry, including psychology, philosophy, and even art history, to bear on the question of the relationship between perception and knowledge, he contributed to the naturalistic approach in the philosophy of science that was gaining in popularity at the time and that challenged, among other things, the possibility of a theory-neutral observation language. More specifically, Machamer claimed that in order to get clear on the epistemological question of the relationship between perception and knowledge, we must carefully consult all relevant areas of inquiry that have something to say about perception. What these various areas of inquiry reveal, he argued, is that our perceptual systems are structured so as to affect the ways in which information is received from the external world. This highlights the notion—central to Machamer's approach—that knowledge is intimately shaped by a variety of factors, including biological predispositions, expectations, theoretical commitments, and values.

In advocating that philosophers draw from other domains of knowledge in order to address philosophical problems, Machamer's research prompted interest in the philosophy of the special sciences—including anthropology, psychology, and sociology—at a time when physics was still the primary target of analysis and inquiry

in the philosophy of science. Machamer instructed us by example that if we are to bring the results of the human sciences to bear on philosophical problems, we need to have a proper philosophy of each of these areas of science. To this end, much of his recent work in contemporary philosophy of science has focused on the nature of theory, method, and explanation in the mind-brain sciences (e.g., *Mindscape*s (1997), *Theory and Method in the Neurosciences* (2001)). Other work has focused on clarifying the role values play in shaping inquiry and knowledge production in science more generally and determining what the implications are (e.g., *Science, Values, and Objectivity* 2004).

Machamer's general focus on issues that arise from scientific practice is also reflected in his important contributions to debates about the nature of scientific explanation. His paper with Lindley Darden and Carl Craver entitled "Thinking about Mechanisms" (2000; hereafter MDC) was inspired by the insight that explanatory practices in the sciences often do not conform to well-entrenched philosophical analyses, such as the covering-law model of explanation. It is the most cited paper ever published in the journal *Philosophy of Science*'s 80-year history (the paper has over 1150 citations). MDC introduced the idea that explanations in the biological and neurosciences could best be understood as describing mechanisms, insofar as such explanations identified the entities and activities productive of phenomena to be explained. To take one of their key examples, neural transmission is a phenomenon that is explained by appeal to the depolarization (activity) of a presynaptic neuron (entity), which results from the opening (activity) of ion channels (entities) and leads to the release (activity) of neurotransmitter (entity) into the synaptic cleft (entity) and binding (activity) of neurotransmitter (entity) to receptors (entity) which become activated (activity) on the postsynaptic neuron (entity). As MDC argue, the accuracy of their account is supported by countless similar examples of explanations in the biological and neurosciences. The paper instigated new interest in the nature of explanation and methodology in the biological and neurosciences. Several papers in this volume reflect this influence.

MDC also harkened back to Machamer's work on the mechanical philosophy, insofar as Boyle, Descartes, Galileo, and Hobbes all sought explanations of phenomena that appealed to the entities and activities that brought them about. This demonstrates that Machamer's work, despite its enormous breadth, is marked by some core themes, and it also shows that Machamer's philosophy of science is profoundly influenced by historical investigations. In this vein, his historical scholarship is typically geared toward addressing, stimulating, or provoking topics and discussions in contemporary philosophy of science.

This volume, while certainly not engaging with the entirety of Machamer's scholarly work in a comprehensive fashion, offers various snapshots of the ways in which his legacy can be seen in the works of his students, both because they continue to work on some of his key ideas and because they echo his method: they demonstrate a sensitivity to both contemporary and historical scientific practices and explore their conceptual, social, scientific, or otherwise systematic implications. We briefly account for these contributions here.

Benjamin Goldberg's essay explores a familiar concept from the philosophy of science, underdetermination, in an unfamiliar context, explanation. Underdetermination is usually deployed in the realism debate or in discussions of theory confirmation. Here, instead, Goldberg is concerned with how underdetermination, interpreted as the necessity of background assumptions, can help us understand a specific historical case involving a dispute about explanatory success. Goldberg examines the work of William Harvey, discoverer of the circulation of the blood, and his rejection of materialist modes of explanation in *De generatione animalium* (1651). He articulates the nature of three background assumptions which affect Harvey's conception of (1) *how* to explain, (2) *what* to explain, and (3) the larger *explanatory stakes* of scientific activity.

Following Goldberg's focus on explanation, Maarten van Dyck reassesses Simon Stevin's mechanics by focusing on how Stevin tried to anchor his mathematical demonstrations in the behavior of material instruments. He shows how his views on the relation between *spiegheling* (speculation) and *daet* (practice) are crucial in correctly understanding his famous proof of the law of the inclined plane and his experimental test of the Aristotelian law of free fall. Van Dyck shows that the distinction between *spiegheling* and *daet* is reproduced in that between instruments at rest and instruments in motion, because of Stevin's claim that impediments to motion are "inseparable accidents" of all moving objects.

David Marshall Miller explicitly engages with Peter Machamer's and Andrea Woody's notion of a *model of intelligibility* (MOI), a concrete phenomenon that guides scientific understanding of problematic cases. His paper extends Machamer and Woody's analysis by elaborating the semantic function of MOIs. He argues that MOIs are physical embodiments of theoretical representations. Therefore, they eliminate the interpretive distance between theory and phenomena, creating classes of concrete referents for theoretical concepts. Meanwhile, MOIs also provide evidence for historical analyses of concepts, like "body" or "motion," that are otherwise thought to be too basic for explicit explication. He illustrates these points with two examples from Galileo. First, he shows how the introduction of the balance as an MOI led Galileo to reject the Aristotelian conception of elemental natures. Second, he shows that Galileo's rejection of medieval MOIs of circular motion constrained the reference of "conserved motion" to curvilinear translations, thereby excluding the rotations that had been previously included in its scope. Both uses of MOIs marked important steps toward modern classical mechanics.

Brian Hepburn expands Miller's treatment of MOIs, focusing on the explication of motion through modeling by simple machines such as the lever and pendulum. He shows that a central way of spelling out the explanatory value of these models is through the concept of equilibrium. Natural motion and simple machines allow the simplification of complex problems in terms of self-evident, intelligible equilibrium conditions. He connects the theme of equilibrium to natural and pendular motion, as well as to mental models in Aristotle, Galileo, Descartes, and Newton. His essay shows that just as equilibrium is a useful model within science, it is also a useful model for doing history and philosophy of science: a normative but objective representation of the important properties of science and its transformation.

Francesca di Poppa turns away from mechanistic explanation to consider a less studied epistemic notion: superstition. She shows that Spinoza connects superstition and piety with the problem of political stability via the notion of obedience. He uses the term "superstitious" to label religious attitudes and practices that promote civil disobedience by establishing demands of allegiance, on the part of the religious authority, that compete with those of the government. Contrary to existing interpretations, di Poppa shows that for Spinoza "superstition" is not characterized by features such as intolerance and anti-intellectualism. In particular, she shows that in the *Theological-Political Treatise*, practices are labeled as pious, rather than superstitious, precisely because they foster obedience and therefore stability, independently of their epistemological valence. She demonstrates how one of Spinoza's goals was to show that what counted as piety among the ancient Jews should be considered superstitious in the more modern, diverse society of the seventeenth-century Dutch Republic and that *libertas philosophandi* was the best way to inoculate a society (if not every single individual) against seditious superstition.

Like other contributors to this volume, Heather Douglas, in a paper entitled "Science, Values, and Citizens," develops a theme she first started working on under the supervision of Peter Machamer and with which she has since opened important new avenues of research: that of the role of values in science. Here, she extends her previous work in considering current debates about public engagement with science, arguing that the central goal of science literacy should not be an understanding of specific scientific facts, but rather of science as an ongoing process of evidence gathering, discovery, contestation, and criticism. Citizens, she argues, should feel that their voice is heard in this process. She distinguishes between various ways in which citizens can engage with the scientific process, specifically honing in on the contestation of research on the basis of values.

In general terms, we can situate the topic of Douglas's article within a broader current in history and philosophy of science, one that looks at the role of science in a liberal democracy and at the role of philosophers as reflecting on science in a political and value-laden context. Warren Schmaus, in his article, "Political Philosophy of Science in Nineteenth-Century France: From Comte's Positivism to Renouvier's Conventionalism," also makes a contribution to this literature, aiming to clarify what the expression "political philosophy of science" might mean. Drawing on a number of historical and contemporary figures (from nineteenth-century French positivism to the more recent works of authors like Kitcher and Longino), he offers a taxonomy of different ways in which philosophy of science can be political. While not endorsing any of these models as the "right" one, he takes his analysis as potentially informing the contemporary debate by offering valuable analytical clarifications.

Schmaus's paper, by virtue of engaging historical material to address a systematic question, exemplifies one of the distinctively Machamerian styles of doing history and philosophy of science identified above. In a similar vein, Uljana Feest's paper, "Physicalism, Introspection, and Psychophysics: The Carnap/Duncker Exchange," takes a debate from the history of early twentieth-century philosophy of science (between the philosopher Rudolf Carnap and the psychologist Karl Duncker)

to address the question of the relationship between philosophy and psychology. While this debate has its unique historical context, having to do with the positivist analysis of language as philosophical method, Feest argues that this context may have prevented Rudolf Carnap from seeing that his philosophical tenets were deeply rooted in nineteenth-century psychophysics, a fact that is still largely unknown in contemporary history of analytical philosophy. Feest draws these conclusions in part by looking past Carnap's rhetoric to the kinds of psychological research practices suggested by his argument, as well as to the research practices of then-current psychology.

Jacqueline Sullivan's article, "Long-term potentiation: One Kind or Many?," also makes explicit reference to scientific practice as a driving force of her research, emphasizing that a major impetus she took away from her training with Peter Machamer was his insistence that philosophy of science, if it is to be relevant, should start out not from philosophical fictions about science but from detailed investigations of specific scientific disciplines (in her case, neuroscience) as it is actually practiced. She argues that the experimental practices of neurobiology are not conducive to the discovery of natural kinds as they are sometimes conceived of by philosophers of science. She develops this argument by means of a case study about the history of research on long-term potentiation (LTP).

The issue of practice—this time medical practice—comes up again, albeit in quite a different way, in the article by Thomas Cunningham, titled "Health, Disease, and the Basic Aims of Medicine." In this article, Cunningham also draws importantly on Machamer's work on science and values to argue that the philosophy of medicine can move beyond debates about the true meaning of "disease" and "health" once it is recognized that medicine is value-laden and that patients and clinicians negotiate whether patients' health states are sufficiently dysfunctional to warrant medical intervention.

The last four papers of this volume take as their points of departure the work on mechanistic explanation that was spearheaded by Carl Craver when he was working with Peter Machamer and Lindley Darden. In his article, "Stochastic Supervenience," Craver explores some of the ontic (and, ultimately, metaphysical) commitments underlying the mechanistic position for which he is well known. This position, which found its most prominent exposition in MDC, importantly presupposes an ontic commitment to a deterministic causal structure of the world. Craver raises the question of what the ontic commitments of interlevel mechanistic explanations are, where the explanandum phenomena stand in a supervenience relation to the underlying explanatory mechanisms. Using the possibility of stochastic supervenience as a contrast class and intuition pump, Craver concludes that mechanists are committed to a thesis of strong (i.e., metaphysical, as opposed to merely nomological or physical) supervenience.

Two papers in this volume specifically engage with key aspects of the MDC article that are of particular importance to Peter Machamer, i.e., the concept of activities and the concept of schemata (or schemas). While the characterization of mechanisms as being comprised of entities and activities is well known and cited often, the precise notion of activities remains controversial. In his contribution,

"Activities Are Manifestations of Causal Powers," Gualtiero Piccinini offers a philosophical analysis of this concept that respectfully disagrees with Machamer's own account in "Activities and Causation: The Metaphysics and Epistemology of Mechanisms" (2004). While Machamer proposes an ontology of entities and activities as separate and irreducible to one another, Piccinini argues that activities are properties of entities. More specifically, they are manifestations of causal powers of entities.

Catherine Stinson, in her contribution, entitled "Back to the Cradle: Mechanism Schemata from Piaget to DNA," picks up on the notion of a *mechanism schema*, as it was first introduced in the MDC article, as an abstract representation of a mechanism. In trying to make sense of the notion of a schema, Stinson makes the original move of taking seriously a suggestion made to her (in conversation) by Peter Machamer, namely, that his intended usage of the term "schema" is similar to the way in which the term was used by the developmental psychologist Jean Piaget. Talking about children's cognitive development, Piaget had argued that cognitive schemata, while reflecting previous experience, are tried out, adapted, and modified in response to novel experiential circumstances. This way of understanding the concept, Stinson argues, can serve to elucidate the research process better than other interpretations, which have tended to treat schemas as a mere stage on the way toward more detailed knowledge of a given mechanism. In the second part of her paper, Stinson goes on to provide an account of how abstract schemata can be explanatory.

Like the previous two articles, Tom Seppalainen's paper, "MOCing Framework for Local Reduction," also engages with Peter Machamer's work on mechanisms, focusing on the way in which it can contribute to an analysis of vision research. He critically discusses the concept of a "linking proposition," introduced by the vision scientist Davida Teller (1938–2011). Such propositions express hypotheses about relations of isomorphism between neural and experiential states and are (according to Teller) a crucial part of a reductionistic research strategy within vision science. Seppalainen argues that Teller's model of research is descriptively and normatively inadequate when it comes to research on color vision. Specifically, he argues (a) that the integration of the psychological and the neurological domain occurs through a unifying concept of color processing, called "cancelation," and (b) that Peter Machamer's mechanistic approach, specifically his notion of *activity types*, provides the conceptual resources for a more promising analysis of research in vision science.

Albany, NY, USA — Marcus P. Adams
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