George Borg

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EDUCATION

2020: Ph.D. History and Philosophy of Science, University of Pittsburgh
Dissertation: Science, labor, and scientific progress
2012: M. A. Philosophy, Tufts University
2007: Ph.D. Organic Chemistry, Harvard University
1999: B.S. with High Honors, Chemistry, University of California, Berkeley, California

INTERESTS

AOS: General Philosophy of Science, Theories of Scientific Change, Science and Technology Studies
AOC: Bioethics, Logic, Philosophy of Social Science, History of Philosophy of Science, History of Science (especially chemistry and the Scientific Revolution), Marx and Marxism

PEER-REVIEWED ARTICLES

(2020) On "the Application of Science to Science Itself:" Chemistry, Instruments and the Scientific Labor Process. *Studies in History and Philosophy of Science*, 79, 41-56. https://doi.org/10.1016/j.shpsa.2019.05.008.

(2019) Discovery and instrumentation: how surplus knowledge contributes to progress in science. *Perspectives on Science*, 27(6), 861-890. *Project MUSE* muse.jhu.edu/article/743378.

INVITED ARTICLES

(2019). Review of M. Mizrahi (Editor). (2018). *The Kuhnian Image of Science: Time for a Decisive Transformation? Philosophia*

PEER-REVIEWED PRESENTATIONS

(2020) Discovery and instrumentation: how surplus knowledge contributes to progress in science. Center for Philosophy, University of Lisbon

(2018) Science, labor and scientific progress. *Société de philosophie des sciences*, Nantes, France

(2018) Accentuating the Positive: Observation and Measurement in Kepler's Optics. *Measurement at the Crossroads*, Paris

(2016) On the Application of Science to Science Itself: Chemistry, Instruments and the Scientific Labor Process. *Society for Philosophy of Science in Practice*, Rowan, NJ

CONFERENCE ORGANIZATION

(2016) Co-organizer of the 18th Annual Pitt/CMU Graduate Student Philosophy Conference, April 8th-10th.

INVITED VISITS

(2019) Max-Planck-Institut für Wissenschaftsgeschichte, Berlin, March 10-16

NON-ACADEMIC PRESENTATIONS

(2017) Questions éthiques sur la mort assistée. Présence Philosophique Le Puy, Le Puy-en-Velay, France

(2016) Les origines, la nature et l'objet de la philosophie des sciences. Radio Chrétienne Francophone, France

AWARDS AND GRANTS

(2020) Science History Institute Short-Term Fellowship
(2018) Wesley Salmon Fund Grant, University of Pittsburgh
(2016) Wesley Salmon Fund Grant, University of Pittsburgh
(2000-2003) National Science Foundation Predoctoral Fellowship

TEACHING

University of Pittsburgh
Spring 2020: Ancient Myth and Science (independent instructor)
Fall 2019: History and Philosophy of the Scientific Revolution (independent instructor)
Morality and Medicine (independent instructor)
Summer 2019: Morality and Medicine (independent instructor)
Spring 2019: History and Philosophy of the Scientific Revolution (independent instructor)
Fall 2018: Morality and Medicine (independent instructor)
Spring 2017: Morality and Medicine (independent instructor)
Fall 2016: History of Philosophy of Science (independent instructor)
Spring 2015: Einstein for Everyone (teaching assistant)
Fall 2014: Morality and Medicine (teaching assistant)

Tufts University
Spring 2012: History of Early Modern Philosophy (teaching assistant)

Harvard University
Spring 2001: Organic Chemistry of Life (teaching assistant)
Fall 2001: Organic Chemistry of Life, Part II (teaching assistant)

GRADUATE COURSEWORK

University of Pittsburgh
Philosophy of Science, Batterman, Fall 2013
Theory of Knowledge, Humphreys, Fall 2016
Aristotle's Philosophy of Science, Lennox, Fall 2013
Explanations, Causes and Mechanisms, Bogen & Machamer, Fall 2013
Laws of Nature, Mitchell, Spring 2014
Epistemology of Experimental Practices, Mitchell & Chirimuuta, Spring 2017
Experiment and Scientific Practice, Chirimuuta, Spring 2015
Models and Modeling in Science, Mitchell & Woodward, Spring 2016
History of the Life Sciences, Olby, Spring 2014
Darwin: Some of the Origins of the *Origin*, Lennox, Fall 2014
History of the Physical Sciences, Palmieri, Spring 2015

Scholasticism, Palmieri, Fall 2015
Descartes Scientist, Manders, Fall 2015
The Ocular Revolution, Baker, Spring 2016
Topics in Philosophy of Physics, Norton, Fall 2013
Philosophical Issues in High-Energy Physics, Perovic, Spring 2014
Einstein, Norton, 2015
Game Theory, Seidenfeld, Spring 2014
Philosophy of Economics, Zollman, Fall 2015

Tufts University
Philosophy of Social Science, Epstein, 2010
Metaphysics, Epstein, 2010
Logic, Smith, 2011
History of Modern Philosophy, Olfert, 2011
Science Before Newton (audit), Smith, 2011
Newton's Principia (audit), Smith, 2012
Ethical Theory, Baz, 2010
Feminist Philosophy, Bauer, 2010
Merleau-Ponty's Phenomenology, Baz, 2010
Voltaire & Rousseau, Hakim, 2012
Philosophy of Law, Kelly, 2010

SCIENTIFIC RESEARCH

(2011-2013) Consultant, Nimbus Therapeutics
(2010-2011) Consultant, Concert Pharmaceuticals
(2007-2010) Scientist, Concert Pharmaceuticals
(2003) Research Associate, Amgen Inc.
(2000-2007) Research in synthetic organic chemistry, Harvard University
(1998-2000) Research in synthetic organic chemistry, University of California, Berkeley

SCIENTIFIC PUBLICATIONS

(2011) Effect of Counterion Structure on Rates and Diastereoselectivities in α,β-Unsaturated Iminium- Ion Diels-Alder Reactions Marcoux, D.; Bindschädler, P.; Speed, A. W. H.; Chiu, A.; Pero, J. E.; Borg, G. A.; Evans, D. A. *Org. Lett.* **2011**, *13*, 3758.

(2008) Evaluation of a Series of Naphthamides as Potent, Orally Active Vascular Endothelial Growth Factor Receptor-2 Tyrosine Kinases Weiss, M. M.; Harmange, J-C; Polverino, A. J.; Bauer, D.; Berry, L.; Borg, G. *et al. J. Med. Chem.* **2008**, *51*, 1668-1680.

(2008) Naphthamides as Novel and Potent Vascular Endothelial Growth Factor Receptor Tyrosine Kinase Inhibitors: Design, Synthesis and Evaluation Harmange, J-C; Weiss, M. M.; Germain, J.; Polverino, A. J.; Borg, G.; *et al. J. Med. Chem.* **2008**, *51*, 1649-1667.

(2002) Remarkably Stable Tetrahedral Intermediates: Carbinols from Nucleophilic Additions to *N*-Acylpyrroles Evans, D. A.; Borg, G.; Scheidt, K. A. *Angew. Chem. Int. Ed.* **2002**, *41*, 3188.

(2001) Asymmetric Synthesis of Pre-Protected α,α-Disubstituted Amino Acids from *tert*-Butanesulfinyl Ketimines Borg, G.; Chino, M.; Ellman, J. A. *Tetrahedron Lett.* **2001**, *42*, 1433.

(2000). Asymmetric Synthesis of Amines and α,α-Disubstituted Amino Acids from tert-Butanesulfinyl Ketimines. Poster, American Chemical Society, San Francisco

(1999) One-Pot Asymmetric Synthesis of *tert*-Butanesulfinyl-Protected Amines from Ketones by the *in situ* Reduction of *tert*-Butanesulfinyl Ketimines Borg, G.; Cogan, D. A.; Ellman, J. A. *Tetrahedron Lett.* **1999**, *40*, 6709.

PROFESSIONAL SERVICE

(2016-present) HPS graduate student liaison with Graduate Student Organizing Committee-United Steelworkers.

(2016-2017) Graduate Student Office Manager, Department of History and Philosophy of Science, University of Pittsburgh.

AFFILIATIONS

American Philosophical Association, American Chemical Society, Society for Philosophy of Science in Practice

LANGUAGES

English (native)
French (fluent)
German (can read with a dictionary)

REFERENCES

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DISSERTATION ABSTRACT

My dissertation introduces a new materialist theory of scientific progress built on a novel characterization of scientific work and an analysis of progress appropriate to it. Philosophers of science have long been interested in scientific change, but they have been mainly focused on how cognitive objects—theory, experiment, evidence, etc.—change. My dissertation argues that this focus is insufficient to answer two crucial questions for understanding scientific progress:

Why is it possible for scientists at a given time to have more epistemic abilities than scientists at an earlier time?

How can knowledge acquired in the past be used in on-going or future research?

I argue that these questions are best answered by analyzing science as a form of labor. The elements of the labor process, involving both intellectual and material means, provide a starting-point for the systematic study of how scientific abilities evolve.

Using this approach, I develop a novel model of scientific change that, I argue, is better at explaining the growth of scientific abilities then classical models like Thomas Kuhn's (among others), because it, unlike the classical models, incorporates changes in instrumentation and systems of labor. In virtue of its focus on the instrumental contribution to scientific research, my model explains how knowledge acquired in the past can be applied in on-going research: it brings out distinctive properties of instruments, largely ignored in the classical models, that allow prior knowledge to be brought to bear.

As a unit of analysis, the labor process exposes features of the dynamics of knowledge accumulation that traditional analyses do not. I analyze historical cases from chemistry and the Scientific Revolution, attending carefully to how scientific work is conducted and conceived.

First, the evolution of scientific abilities depends on ambient ideological conditions: Social attitudes towards different kinds of work are critical, as are scientists' own notions about the proper object of science and the value of technology. I demonstrate these effects of ideological conditions through a historically-driven analysis of the emergence of the scientific method in Europe's early modern period.

Second, I argue that scientific progress consists not just in the growth of theoretical or empirical knowledge, as in traditional philosophy of science, but also in the growth of abilities. The tools of science play a crucial role in determining the abilities scientists can and must have to do science. Tools also determine how scientists' abilities change over time, by enabling, but also constraining, the incorporation of knowledge into the labor process. I bring a new perspective to the idea that science is furthered by instrumentation. They do not just enhance our senses, which is the standard view. To it, I add that they initiate a positive feedback loop between the production of new knowledge and instrument construction. This process requires the integration, and transformation into material form, of different kinds of knowledge. As the process is repeated over the long term, scientific work is transformed because it becomes less dependent on native human epistemic abilities.

This view refreshes the topic of scientific discovery, which has traditionally been treated as a one-way avenue leading from the scientific method to novelty. In contrast, my view is of a spiraling process, in which discoveries are conceived as a surplus, and hence as having potential uses that can be incorporated into scientific practice for further rounds of discovery.

I showcase these claims on a concrete historical case drawn from the history of 20th century chemistry that has not been much discussed in the philosophy of science. The

"Instrumental Revolution in Chemistry," as it has been called, involved a revolution in the analytical methods of chemistry. On a traditional, theory-centric view, this episode would largely be a story about the development of quantum mechanical theory and its application in chemistry. On my view, this has to be understood as a transformation of labor. It is true that each new method was based on a physical phenomenon, most often quantum-mechanical. But the initial phenomenon was generally inapplicable for other than specialist use until the instrument used to detect it, and the techniques for its use, were transformed in order to adapt them to the chemical context. Conversely, the adoption of the instruments entailed a transformation of analytical work in chemistry. Thus viewed, I argue that the Instrumental Revolution appears as one instance of a recurring pattern of scientific revolution caused by radical changes in the means of scientific work.

The question of dynamics may be put in broader perspective by considering the well-known fact that starting roughly in the 1980s, the history and philosophy of science took what has been called the "turn to practice." This turn involved a shift in research focus from the finished products of science—theories and facts, for pre-turn historians and philosophers—to the nature of scientific practice. Though my work is clearly inscribed within the practice turn tradition, it combines that tradition with an older concern for the nature and causes of scientific progress. This older tradition, however, tended to view progress as either incremental or discontinuous. Incrementalists emphasized the gradual incorporation of past achievements into present theories. Discontinuists, on the other hand, emphasized revolutionary episodes in which theories are overthrown and replaced by superior competitors. My view is that science is constantly transforming itself by incorporating prior knowledge into its own practices. There is indeed a revolutionary aspect. But there is also an incrementalist aspect, in that the transformation occurs by the integration of prior knowledge into present practices. The conception of a discovery as a surplus, and hence as having a potentially transformative role in the reproduction of scientific practice, is important for appreciating these dynamics.