

New Trends in Philosophy of Biology: Mathematics Models, Ethics and Politics

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The purpose of the leave is to complete a book that develops my ideas about scientific rationality applied to the philosophy of biology. I will focus on the organization and interpretation of data collected in field experiments, the complexity of biological systems, and how their study intersects with important epistemological, ethical and political issues.

During my career as a philosopher, my work has been characterized by the use of historical episodes in mathematics and physics as case studies. For example, my 2016 Springer book *Starry Reckoning: Reference and Analysis in Mathematics and Cosmology*, studied episodes in number theory and in modern cosmology. It won the 2017 Fernando Gil International Prize for Philosophy of Science, and so my recent public lectures have been devoted to those topics. However, over the past decade I have also been developing an interest in the history and philosophy of biology. This interest has dominated my teaching, whether I teach philosophy of science at the introductory level, or to older undergraduate and graduate students, and has resulted in a number of publications and collaborations. My current aim is to write a new monograph, applying the ideas I developed in the 2016 book, and also my 2007 OUP book, *Representation and Productive Ambiguity in Mathematics and the Sciences*, to the biological sciences and their intersection with ethical and political issues. In these books, I argue that the growth of knowledge often takes place at the overlap of disparate areas of research, and sometime at the overlap of disparate discourses within a relatively unified area of research, and then I explain in some detail how this expansion of understanding takes place historically. Thus up till now, my focus has been on the growth of knowledge, but at this point I will also focus on how empirical data is collected and organized, and used for making predictions and recommendations that affect policy decisions.

There are theoretical, personal, and pedagogical reasons for this shift, which inform my new project. The theoretical heart of the matter, is that as a philosopher I have always argued against 'reductionism,' the intellectual habit that dominated Anglophone philosophy of science throughout most of the twentieth century. It was suggested by

Bertrand Russell that arithmetic and geometry could be reduced to – by which he meant logically deduced from – predicate logic, and this inspired the hope that biology and chemistry could analogously be deduced from the principles of physics. Three chapters in my 2007 book contest this claim in some detail; there I show that both chemistry and biology make use of mathematical models, which help shape the understanding of empirical data in those fields, but that the models are different from those used in physics, since the objects and systems studied are so different from the objects and systems studied by physics. The overlap between physics and chemistry, and between chemistry and biology, is very important to the advance of knowledge, but the interaction among domains cannot be reduced to a neat deduction within a unified theory. Living things especially resist reduction because they have, even at the simplest levels, a kind of intentionality linked to function and action.

The personal dimension is that one of my brothers is a marine biologist at the University of California at Davis, Ted Grosholz, who studies (with the help of the ‘Grosholz Lab’) population dynamics, community ecology, and invasive species. My best friend from high school, Ruth Geyer Shaw, is a population geneticist who works with one of her brothers (a mathematician, Charles Geyer) at the University of Minnesota, and among other things studies the effects of the fragmentation of the midwestern prairie on various populations of prairie plants, using the Aster Models for life history analysis that she and her brother developed. She just stepped down as the editor of the journal *Evolution*. So I have been following their work with great interest for decades, and in 2011 I published an essay about the philosophical implications of Aster Models in *Studies in the History and Philosophy of Biological and Biomedical Sciences*. Recently, I’ve noticed that the work of both of them has acquired an ethical and political dimension: my brother was part of an (effective) effort to rid the San Francisco Bay of invasive grasses, and Ruth has been writing about (effective) methods to identify organisms that are under stress, and propose methods to strengthen and save them.

A couple of years ago, I recruited and funded one of our philosophy majors (Alex Grigas, who was chosen to be our student marshal last spring, and was also a biochemistry major, working in Penn State’s Keating Lab investigating the ‘origins of life’) to work with Ruth for a couple of weeks at her field sites studying the ability of

Partridge pea, *Chamaecrista fasciculata*, to adapt to rapid environmental change, in three places in Minnesota and Iowa. At the same time, I recruited and funded one of our graduate students (Tano Posteraro, who is working on the philosophy of the life sciences, inspired by the writings of French philosopher Henri Bergson) to work with Ted at his websites along the California coast. I thought it was important for a student working in a lab, and a student studying philosophy, to experience the hard, material, inspiring nature of fieldwork and learn how scientists collect and make sense of the data they collect out in the wild. Both students made excellent use of their time at the field sites, talked to a variety of scientists and philosophers of science at both universities, and wrote up detailed and reflective reports. I used those reports in the co-authored article “Scientific Discovery and Inference: Between the Lab and the Field in Biology,” which appeared this summer in the journal *Topoi*, a Springer Nature journal.

One of the notable ideas I learned from Alex’s and Tano’s reports is the growing importance of how data is collected, processed and understood. One of Ted’s colleagues is Pamela Reynolds, who is Project Coordinator of the Data Science Initiative. Tano spoke with her a great deal, and learned that, for example, gene sequencing technology leads to a rather philosophical problem: how to distinguish information from noise? It also raises another problem: how to coordinate different data sets across disciplines? Genbank, the NIH Genetic Sequence Data Base, is a case in point. An increasing output of genetic information makes processing algorithms, collation software, natural language processing and machine learning programs indispensable tools for integrating data across fields. But the conceptual assumptions that organize this technology deserve scrutiny: What defines a species? What defines an invasive species? How should we measure biodiversity or stability in a given area: more generally, how do we assess the health of an ecosystem? Alex encountered similar issues in Ruth’s current project studying Partridge pea: it is not a simple matter to quantify how well an organism flourishes in an environment. Her group is studying, empirically and quantitatively, how well the potential rate of adaptation predicts realized adaptation in natural populations, and how a population’s genetic variability affects the rate of adaptation over several generations. The scientific import of this research also has an ethical and political aspect, for it aims to

facilitate assessments of whether populations can adapt rapidly enough to keep up with the pace of climate change.

Once I realized how important this issue is, I also realized that I have a number of resources for exploring the issue in the work of three of my former graduate students, two at the University of Rome ‘La Sapienza,’ and one in the College of Medicine at the University of Florida, Gainesville. Emiliano Ippoliti is now a professor at the University of Rome, and Giulia Miotti just received her doctorate under his direction; I served on both dissertation committees (in 2004 and 2017) and they both came to Penn State for a number of months to work with me. As it happens, they have both recently studied the use of data collection in economics, its cogency, meaning and human impact. Amanda Hicks has been working on Biomedical Informatics, focusing on the way that computers employ relationships among words, concepts and categories, what a philosopher would call ontology, how to sort out the things that make up reality, in this case as it impinges on human medicine. She develops ‘semantic networks’ that support machine reasoning with language, data and text. Economics and medicine flank biology: the complexity of our cultural economic and medical institutions stand in analogy to the complexity of biological systems, and their study raises similar problems about sorting noise from information, and using information to address ethical and political problems. So I look forward to learning more from, and collaborating with, my former students.

The topic of ‘big data,’ studied both for its use as a mathematical model to help us complicate our understanding of complex systems, and for its unforeseen ethical implications, has also put me into novel interaction with colleagues here at Penn State. Jonathan Marks is Director of the Bioethics Program in the Rock Ethics Institute, and works both as a professor in the Philosophy Department and in Penn State Law’s School of International Affairs. He is interested in the misuse of data collected in the course of health care, in this country and around the world, and directed my attention to the work of Lawrence Gostin at Georgetown University’s Law Center, and that of Adam Tanner, at Harvard’s Institute for Quantitative Social Science. I also talked with Ted Toadvine, Director of the Rock Ethics Institute; both he and Jonathan brought my attention to two young colleagues who have just become Research Associates at the Rock: Daniel Susser and Sarah Rajtmajer. They are both concerned with the ethical dimensions of data

collection; she has a background in mathematics and the collection of intelligence data, and he has a background in computer science and law. I look forward to talking with both of them.

I also went back to my colleague in the Philosophy Department, Paula Droege, who has often helped me think about issues related to the philosophy of biology. She has been working intensively on the philosophical issues involved in neuroscience for many years, explored in her earlier book and her current book project, and her reflections also include consideration of 'big data.' Recently, she was invited to be a key note speaker at the Symposium "Reconsidering Humanity: Big Data, the Scientific Method, and the Images of Humans," at the University of Gothenburg, Sweden; her presentation has become the essay "Not by Data Alone: The Promises and Pitfalls of Data Analysis in Understanding Consciousness," forthcoming in the *European Review*, which I am now in the process of discussing with her. These investigations into the ethical and epistemological issues raised by 'big data' in economics, medicine, law and policy, and neuroscience clearly diverge from my own book project; yet in my experience as a scholar, engaging with people who are working at the edges of one's own field of focus can be quite illuminating, and can lead to unexpected insights.

The other pedagogical dimension of my thinking about this book-in-process has emerged from the way I teach the philosophy of science at the introductory and higher levels, over the past decade. I always use a concrete case study to bring the abstract dialectic conducted by philosophers of science down to earth. Recently, the case study has been either cosmology or biology. When I teach biology, we begin with the standard mid-century, logicist account of scientific rationality, offered by philosophers who fell in love with predicate logic and the beginnings of computer technology, and Newton's physics and Einstein's reformulations of it. Then we read books by Richard Lewontin, Evelyn Fox Keller, Stephen Jay Gould and others, who explain why the subject matter and methods of biology challenge this view of scientific reasoning in an especially dramatic way. Then we read works by Wangari Maathai, Vandana Shiva, John Leary and others, who bring the study of biology into direct relation with issues of ecological stability, food and hunger, and climate change, with special emphasis on the importance of forests. Last fall, I followed the campus component of Forestry 203, with the kind

permission of Eric Burkhart and Margo Kaye, and hope to work further with them and the Department of Ecosystem Science and Management, developing part of my book apropos local issues about the health of our forests, here in Penn's Sylvania.

My husband Robert Edwards (English and Comparative Literature) plan to take a sabbatical year at the same time; we have both put off our sabbatical, so that he could help out as Head of Comparative Literature for one more year. Our plan is to stay here, in July, August, September and the first half of October. During that period, I hope both to visit Ted and Ruth and their research sites, and to interact with my colleagues in the Department of Ecosystem Science and Management, and locate a good case study there. From mid-October to mid-December, we have obtained an apartment in Rome, and I will be working intensively with my two former students, as well as my colleague the philosopher Carlo Cellucci, now emeritus but still very active.

We'll come back home for a few months, and then spend most of the spring at Clare Hall, University of Cambridge, where we are both Life Members. I will work in the Cambridge University Library (a block away from Clare Hall), and look forward to reviving my interaction with philosophers who focus on ethics, like Onora O'Neill at Cambridge and Susan James at Birkbeck College, University of London, and those who focus on the philosophy of science, like Donald Gillies, emeritus in the Department of Science and Technology Studies, University College London, Jeremy Butterfield at Cambridge, and Brendan Larvor at the University of Hertfordshire. I am also in the process of reaching out to Barry Smith, Director of the Institute of Philosophy in the School of Advanced study at the University of London, Anil Seth at the Sackler Centre for Consciousness Science at the University of Sussex, as well as colleagues who work in the area of Conservation, Behavioral Ecology and Community Ecology in the School of Biological Science at Cambridge. Grateful for the Chunnel, I will often go down to interact with my colleagues at SPHERE, University of Paris Denis Diderot – Paris 7, where I have been an Associate for almost 15 years.

Finally, when I return home, I hope to pay a second visit to Ted and Ruth, going over the chapters I've developed and re-thinking some of the issues with them and some of their philosophical colleagues. I also hope to work with my colleagues in the Philosophy Department, the Bioethics Institute, the Rock Ethics Institute, and the

Department of Ecosystem Science and Management as I complete the book, and go on to develop projects and curriculum related to philosophy of biology, and its intersection with ethical and political issues.

I plan to send my completed book to Springer. My first Springer book, as I mentioned above, won a significant prize, and appeared in the series Studies in Applied Philosophy, Epistemology and Rational Ethics, which would be a good series for the book I have just described; I plan to send this proposal to my editor there, Lorenzo Magnani. My second Springer book is coming out in October. The title of the second book is *Great Circles: The Transits of Poetry and Mathematics*, one of the first books in a new series entitled Mathematics, Culture and the Arts. I should add that in between I published *The Stars of Earth: New and Selected Poems* with Word Galaxy Press (2017), which is full of trees. I plan to complete another book of poetry during my sabbatical year, and to put together a collection of my travel writings, which range from Tokyo to Olympia, Rome, Helsinki, Toronto, and Buenos Aires, with a special emphasis on Paris.

Titles and References

<https://philpapers.org/rec/GROSPW>

My article, “Studying Populations without Molecular Biology: Aster models, and a new argument against reductionism.”

<https://philpapers.org/rec/GROSDA-5>

My co-authored paper, with Tano Posteraro and Alex Grigas, “Scientific Discovery and Inference: Between the Lab and Field in Biology.”

<http://fernando-gil.org.pt/en/nominees/2017/winner/>

Description of my 2016 book, for the Fernando Gil International Prize.

<https://ruthgshaw.wordpress.com/>

This link provides the research and publications of Ruth Shaw’s research group.

<http://www.des.ucdavis.edu/faculty/grosholz/gradstudents.htm>

This link provides the research and publications of Ted Grosholz’s research group.

<http://www.uniroma1.academia.edu/EmilianoIppoliti>

<http://www.lettere.uniroma1.it/users/emiliano-ippoliti>

This two links provides the publications of Emiliano Ippoliti, including a Springer book he co-edited, *Models and Inferences in Science*, which includes two essays I wrote, one with an undergraduate student Kahindo Kamau.

<https://hobi.med.ufl.edu/about/faculty-directory-2/hicks-amanda/>

This link describes the activities and publications of Amanda Hicks.