ALTENBERG SYMPOSIA IN THEORETICAL BIOLOGY

Data Intensive Biology
Why Google Won´t Replace Science

Focal Symposium

14 June 2012
3:00-6:45 p.m.
Hörsaal 2, UZA 1
Biozentrum
Althanstrasse 14, Wien IX.

Rachel Ankeny *Adelaide*

Athel Cornish-Bowden *Marseille*

Sabina Leonelli *Exeter*

Joachim Schummer *Berlin*

Eric Werner *Oxford*

Program

Konrad Lorenz Institute for Evolution and Cognition Research
and
Department of Theoretical Biology, University of Vienna

The Konrad Lorenz Institute for Evolution and Cognition Research (KLI)

The Konrad Lorenz Institute for Evolution and Cognition Research (KLI) is an international center for advanced studies in theoretical biology, located in Altenberg, near Vienna, in the family mansion of Konrad Lorenz, whose work laid the foundation for an evolutionary approach to mind and cognition. The KLI supports the articulation, analysis, and integration of biological theories—primarily in the areas of evolutionary developmental biology and evolutionary cognitive science—and the exploration of their wider scientific and cultural significance. This is accomplished by providing various kinds of fellowships; publishing a book series, *The Vienna Series in Theoretical Biology*, and a journal, *Biological Theory: Integrating Development, Evolution, and Cognition*; and organizing symposia, round-table discussions, and workshops.

For more information, consult our homepage at http://www.kli.ac.at/

The Altenberg Symposia in Theoretical Biology

The KLI organizes symposia of various kinds. In the focal symposia, a small group of experts present their opinion on a scientifically and philosophically important and timely topic. After brief individual presentations of their views, they discuss with each other and with the audience.

The focal symposia are held in lecture hall 2 at the Biozentrum, Althanstrasse 14, Wien IX) on a Thursday, 3:00-6:45 p.m.

A follow-up discussion with the speakers takes place at the KLI, Adolf-Lorenz-Gasse 2, 3422 Altenberg, the next day, 10:15-12:00 a.m. Information on how to reach the KLI can be found in the back of this brochure.

Data Intensive Biology
Why Google Won´t Replace Science

According to science critic James Le Fanu, ours is the “best and worst of times” for science. The best because funding has never been so lavish, publication output never so great, and data generation never more impressive in quantitative terms. Why the worst of times? Critics reprehend that despite the dramatic push of financial investment and deluge of data few new scientific landmarks were set. While until recently, biology raised high expectations by employing high-throughput technologies such as in the Human Genome Project (HGP), the ‘rational’ design of drugs, or personalized medicine, now disillusion takes over more and more. The genome project led to the disappointing finding that humans harbor less genes than weed and that human genes can be functionally replaced by mouse genes. *In silico* drug designers or scientists exploiting experimental model organisms for drug development increasingly exercise an attitude of humility in view of the creativity and richness of three and a half billion years of evolution.

Bioinformatics, computational biology, systems biology (here taken to include genomics, proteomics, and other ‘omics’), and synthetic biology have become data intensive scientific undertakings. High-throughput technologies as first deployed on a massive scale in biology in the HGP raise great expectations within the scientific community and beyond, which range from ‘rational’ drug design or a better understanding of meteorology to “an improved ability to examine history and culture” (Borgman 2010). The explosion of data in ‘big sciences’ such as astronomy, high energy physics, and more recently also in subdisciplines of biology and biomedicine has led to a reinterpretation of what science is and does as well as to the emergence of new fields of study such as astro-informatics and computational biology.

The “Fourth Paradigm” envisioned by Jim Gray (1944-2007), a software designer for Microsoft, calls for a new scientific methodology based on the power of data intensive science, understood as *the capturing, curation, and analysis of large data* (Hey et al. 2009). Its proponents intend this methodology to complement rather than to displace the first (empirical/experimental), second (analytical/theoretical), and third (large-scale computer simulation) scientific “paradigms.” This sounds more plausible than Chris Anderson’s (2008) claim that “with enough data, the numbers speak for themselves,” and that we “can analyze the data without hypotheses about what it might show.” Google, then, is not on its way to displace science.

The big data challenge concerns the scale, breadth, and complexity of the new data sets, whose combined effect is taken to require revolutionary measures for data management, analysis, and accessibility now that “biology is changing fast into a science of information management” (US National Institutes of Health). Although skepticism about the prospect of finding ways to extract useful information from this ‘morass’ is voiced occasionally (e.g., Valencia 2002; Brent 2004), most biologists and computer scientists put their hopes in data driven modeling approaches such as clustering, principal components analysis, and partial least squares analysis, tools for the automated extraction of meaningful pathways from 'omics' data, new visualization techniques, and other technical advances. Some authors (e.g., Hanahan & Weinberg 2000; Woese 2004; Callebaut 2012) count on conceptual and theoretical breakthroughs.

The data torrent poses ethical and political challenges to society, which include big issues about who in democratic societies is to govern bioengineering with its promises of better drugs and even an "elixir of eternal youth" (Antoine Danchin), and more modest questions about the de/regulation of practices of data sharing within scientific communities and between the scientific community and other stakeholders (Strasser 2006; Leonelli 2009; Borgman 2010). Advocates of the "Fourth Paradigm" like to portray it as a means to enhance citizens' participation in science; it is probably too early to judge if such optimism is warranted. In her contribution to the symposium, Rachel Ankeny will critically examine the 'Bermuda principles' that required researchers in the HGP to post their genomic sequence data online for unconditional use by others, and ask to what extent this is a novel scientific practice.

Data intensive biology also raises a number of philosophical issues. This symposium can only focus on some of those:

• *Is big data biology a new kind of science*, *presumably post-reductionistic or even holistic?* To what extent is big data biology data-driven? Can data 'speak for themselves?' In her talk, Sabina Leonelli ponders whether we are witnessing "the rise of a new scientific epistemology" from her practice oriented philosophical perspective, which is informed by empirical studies of data curation.

• *What is 'systemic' about 'systems biology'?* Big data biology turns out to be pretty near sighted when it comes to reflecting on its own conceptual foundations. In an introduction to an issue of *Science* magazine on systems biology, Chong & Ray (2002), referring to Ludwig von Bertalanffy's *General System Theory* (1969), claim that Bertalanffy's "remains an effective definition of systems biology as practiced today with the integration and application of mathematics, engineering, physics, and computer science to understanding a range of complex biological regulatory systems." They go on to argue that the "delay" between Bertalanffy's "early pronouncement" of systems theory and the work presently assembled by systems biologists "was necessary, primarily to accumulate sufficient descriptions of the parts to enable a reasonable reassembly of the whole." Yet, as Athel Cornish-Bowden will argue in his contribution, present day systems biology often seems to be little more than old-fashioned experimental biology practiced on a vast scale and generating mountains of data, but with no real concept of a system as an entity in itself. As a consequence, he feels, it cannot lead to an understanding of life, because living systems can never be understood simply as the accumulation of vast amounts of data.

• *The role of theory.* A century and a half ago, Charles Darwin found it odd that "any-one should not see that all observation must be for or against some view if it is to be of any service!" Latter day believers in "let the data speak for itself" are but repeating a mistake that is as old as modern science itself: "About thirty years ago there was much talk that geologists ought only to observe and not theorize; and I well remember someone saying that at this rate a man might as well go into a gravel-pit and count the pebbles and describe the colours" (Darwin 1861). Current modeling practices in systems biology have been described as "Data without models merging with models without data" (Krohs & Callebaut 2007). In his contribution focusing on developmental control theory, Eric Werner will discuss the challenge of relating lower levels of molecular implementation with abstract theories of developmental control networks, and argue that data gains meaning and relevance only in the light of a theoretical perspective.

• *Knowing through making?* Microbiologist Carl Woese (2004) warned that "a society that permits biology to become an engineering discipline, that allows that science to slip into the role of changing the living world without trying to understand it, is a danger to itself." In the final contribution to this symposium, Joachim Schummer will scrutinize various epistemic claims that revive Giambattista Vico's *verum factum* principle—in a radical form, "What I cannot build, I cannot understand") and argue that synthetic biology's epistemic ambition is questionable (see also Schummer 2011).

References

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Brent R (2004) A partnership between biology and engineering. Nature Biotechnology 22: 1211-1214.

Callebaut W (2012) Scientific perspectivism: A philosopher of science's response to the challenge of big data biology. Studies in History and Philosophy of Biological and Biomedical Sciences 43: 69-80.

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Krohs U, Callebaut W (2007) Data without models merging with models without data. In: Systems Biology: Philosophical Foundations (Boogerd FC et al., Eds), 181-213. Amsterdam: Elsevier.

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Leonelli S (2009) On the locality of data and claims about phenomena. Philosophy of Science 76: 5-14.

Schummer J (2011) Das Gotteshandwerk. Die künstliche Herstellung von Leben im Labor. Frankfurt am Main: Suhrkamp.

Strasser BJ (2006) Collecting and experimenting: The moral economies of biological research, 1960s-1980s. Preprint no. 310. Berlin: Max Planck Institute for the History of Science.

Valencia A (2002) Search and retrieve. Large-scale data generation is becoming increasingly important in biological research. But how good are the tools to make sense of the data? EMBO Reports 3: 396-400.

von Bertalanffy L (1969) General System Theory. New York: Braziller.

Woese CR (2004) A new biology for a new century. Microbiology and Molecular Biology Reviews 68: 173-186.

Werner Callebaut & Isabella Sarto-Jackson (KLI)

Data Intensive Biology
Why Google Won´t Replace Science

Schedule

3:00 p.m.	*Opening* **Gerd B. Müller**, Chairman, KLI **Werner Callebaut**, Scientific Director, KLI
3:10 p.m.	*Promise and Dangers of Data-intensive Research* **Sabina Leonelli**
3:40 p.m.	*Systems Biology: What Became of Systemic Thinking?* **Athel Cornish-Bowden**
4:10 p.m.	*Free and Unfettered? Scientific Communities Meet the Internet Through the Bermuda Principles* **Rachel Ankeny**
4:40 p.m.	Coffee break
5:10 p.m.	*Local and Global Control in Development and Evolution* **Eric Werner**
5:40 p.m.	*Knowing through Making:* *From Synthetic Chemistry to Synthetic Biology* **Joachim Schummer**
6:10 p.m.	*Panel Discussion among the speakers* **Isabella Sarto-Jackson**, Moderator
6:25 p.m.	*Open discussion*
6:45 p.m.	*End*

Sabina Leonelli

ESRC Centre for Genomics in Society (EGENIS)
University of Exeter
http://www.genomicsnetwork.ac.uk/egenis/

Promise and Dangers of Data-intensive Research

The data deluge is upon us, and online databases, visualisation tools and automated data analysis are gaining authority as the best ways to understand the significance of the information available. This talk examines some implications of this shift in research practices within the biological and biomedical sciences. Are we witnessing the rise of a new scientific epistemology? And what opportunities and dangers are associated to it? This talk will consider these questions from a philosophical perspective informed by empirical studies of data curation in model organism biology and plant science.

Selected publications

(2012) Classificatory theory in data-intensive science: The Case of open biomedical ontologies. International Studies in the Philosophy of Science 26: 47-65.

(2012) Re-thinking organisms: The epistemic impact of databases on model organism biology (with R. A. Ankeny). Studies in the History and Philosophy of the Biological and Biomedical Sciences 43: 29-36.

(2010) The commodification of knowledge exchange: Governing the circulation of biological data. In: The Commodification of Academic Research (Radder H, eds), 132-157. Pittsburgh UP.

(2010) Packaging small facts for re-use: Databases in model organism biology. In: How Well Do Facts Travel? The Dissemination of Reliable Knowledge (Howlett P, Morgan MS, eds), 325-348. Cambridge UP.

(2009) Scientific Understanding: A Philosophical Perspective (with H. de Regt and K. Eigner K). Pittsburgh UP.

Leonelli S (2009) On the locality of data and claims about phenomena. Philosophy of Science 76: 737-749.

Centralising labels to distribute data: The regulatory role of genomic consortia. In: The Handbook for Genetics and Society: Mapping the New Genomic Era (Atkinson P, Glasner P, Lock M, eds), 469-485. Routledge.

Leonelli S (2007) What is in a model? Using theoretical and material models to develop intelligible theories. In: Modeling Biology (Laubichler M, Muller GB, eds), 15-35. MIT Press.

Biographical note

Dr. Sabina Leonelli is a senior lecturer at the ESRC Centre for Genomics in Society (EGENIS), U. of Exeter. She studied history, philosophy, and social studies of science at University College London (Bsc), at the London School of Economics (Msc), and at the Vrije Universiteit in Amsterdam. Before moving to Exeter she worked as a research officer in the Leverhulme/ESRC project 'How Well Do "Facts" Travel?' at the LSE.

Dr. Leonelli's approach to the philosophy of science is grounded on the empirical study of scientific practices as informed by historical research, ethnographic methods used in the social and anthropological studies of science and technology, and collaboration with practicing scientists. Her research spans the fields of history and philosophy of biology, science and technology studies, and general philosophy of science. Her current work focuses on the philosophy and sociology of e-science and bioinformatics, especially the rhetoric of 'data-driven research,' its relation to practices of data handling online and experimentation, and the role of digital technologies and automation in biological and biomedical research, particularly model organism biology and plant science. She explores the epistemological and ontological assumptions underlying the choice of taxonomies in bioinformatics (bio-ontologies), and investigates the epistemology of 'data-driven' modes of research. She is also interested in how collective modes of inquiry and division of labor, as instantiated through cyber-infrastructures, affect scientific modes of understanding, and in how technologies for data dissemination and modeling affect scientific integration.

In other historical and epistemological work, Dr. Leonelli focuses on the use of model organisms in the second half of the 20th century, with specific attention to the model organism *Arabidopsis thaliana*. This case, together with her work on bioinformatics, enables her to reflect more broadly on the historical roots and new characteristics of 21st century biology, and particularly on the relation between the knowledge that is produced and recent changes in the infrastructure and institutionalization of research, and between basic and applied modes of research in plant science.

Dr. Leonelli is a member of the KLI.

Athel Cornish-Bowden

CNRS Marseille
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Systems Biology: What Became of Systemic Thinking?

The activity that has become known as "systems biology" has undergone enormous growth in the past decade, from a handful of publications in 2001 to about 1400 in 2011. But what has this to do with systemic thinking as espoused by Ludwig von Bertalanffy, or even the milder version advocated by Henrik Kacser? Apparently very little, and modern "systems biology" often seems to be little more than old-fashioned experimental biology practiced on a vast scale and generating mountains of data, but with no real concept of a system as an entity in itself. The major philosophical objection to most of modern systems biology is that it cannot lead to an understanding of life, because living systems can never be understood simply as the accumulation of vast amounts of data. There are more practical objections as well, as illustrated by the history of antibiotics. Some ten different classes of antibiotics were discovered in the 30 years between 1935 (sulfanoamides) and 1965 (quinolones), but the supply has essentially dried up in the more than 40 years since then, with the oxazolidones (1997) as the sole success, despite the fact that we now have hospital strains of *Staphylococcus aureus* that resist all known antibiotics. This is just one illustration of the fact that combinatorial chemistry and other approaches based on mindless accumulation of huge amounts of data have failed to deliver new drugs at anything approaching the rate that was promised: many useful drugs are enzyme inhibitors, but of these nearly all are derived from traditional remedies (aspirin), accidental discoveries (viagra), or substrate analogues (finasteride); genuine results from what is optimistically called rational drug design are hard to find.

Selected Publications

(2012) Fundamentals of Enzyme Kinetics. 4th ed. Wiley-Blackwell. Orig. 1979.

(2006) Putting the systems back into systems biology. Perspectives in Biology and Medicine 49: 475-489.

(2005) Systems biology may work when we learn to understand the parts in terms of the whole (with Cárdenas ML). Biochemical Society Transactions 33: 516-519

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(1996) Henrik Kacser (1918–1995): an annotated bibliography. Journal of Theoretical Biology 182: 195–199.

Biographical note

Athel Cornish-Bowden was an undergraduate and graduate at Oxford, where he obtained his doctorate with Jeremy R. Knowles in 1967. After three post-doctoral years in the laboratory of Daniel E. Koshland, Jr., at the U. of California, Berkeley, he spent 16 years at the U. of Birmingham, England, first as Lecturer and then as Senior Lecturer in the Department of Biochemistry. From 1987 to 2009 he was Directeur de Recherche in three different laboratories of the CNRS in Marseilles, and from 2009 until the present he has been Directeur de Recherche Émérite. Despite starting his career in a department of organic chemistry, he has done virtually all of his research in biochemistry, with particular reference to enzymes, including pepsin, mammalian hexokinases, and enzymes involved in electron transport in bacteria. Since moving to Marseilles he has been particularly interested in multi-enzyme systems, including the regulation of metabolic pathways. At present his major interest is in the definition of life and the capacity of living organisms for self-organization, but he continues to be involved with computer modeling of metabolic pathways. In addition to his principal areas of research he has long had an interest in biochemical aspects of evolution, and his semi-popular book in this field, *The Pursuit of Perfection* (Oxford UP, 2004), has served in the past two years as the foundation for graduate courses in Belgium and Chile. In 1983 he visited China (Beijing, Shanghai, Nanjing) as the guest of the Academia Sinica, under the auspices of the late Professor Tsou Chen-Lu. In total he has published more than 200 research papers in refereed journals, together with numerous invited chapters in books.

Rachel Ankeny

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Free and Unfettered? Scientific Communities Meet the Internet Through Bermuda Principles

This paper examines the 'Bermuda principles,' drafted in their initial form in 1996, which required researchers in the public Human Genome Project to post their genomic sequence data online daily and for unconditional use by others. The Bermuda principles are often cited as critical to the ethos of contemporary research, particularly to that of broad scale, consortium-based science, and are viewed by some as a key stage in the founding of a new era of online, collaborative research. We examine the validity of this claim, and in particular explore whether the principles helped to shape a novel set of online practices which have become critical to contemporary genomics, or instead whether they merely codified existing norms in the field.

Selected Publications

(forthcoming 2012) Disease and health, concepts and representations. In: History of Contemporary Medical Thought *(*Fantini B, Lambrichs LL, eds). Seuil.

(forthcoming 2012) Re-thinking organisms: The impact of databases on model organism biology (with S. Leonelli). Studies in the History and Philosophy of Science.

(2011) What's so special about model organisms? (with S. Leonelli). Studies in the History and Philosophy of Science 41: 313-323.

(2011) Using cases to establish novel diagnoses: Creating generic facts by making particular facts travel together. In: How Well Do Facts Travel? (Morgan M, Howlett WP, eds), 252-272. Cambridge UP.

(2010) Historiographic considerations on model organisms, or, how the mureaucracy may be limiting our understanding of contemporary genetics and genomics. History and Philosophy of the Life Sciences 32: 91-104.

(2007) Wormy logic: Model organisms as case-based reasoning. In: Science without Laws (Creager ANH, Lunbeck E, Wise MN, eds), 46–58. Duke UP.

Rasko JER, O'Sullivan GM, Ankeny RA, eds (2006) The Ethics of Inheritable Genetic Modification: A Dividing Line? Cambridge UP.

Biographical note

Dr. Rachel A. Ankeny is an interdisciplinary teacher and scholar whose areas of expertise cross three fields: history/philosophy of science, bioethics and science policy, and food studies. In the past five years she has been an academic visitor at the University of Exeter (where she is currently an honorary senior fellow), the London School of Economics, and Arizona State U., and has given invited talks at major institutions including the U. of Michigan, Duke U., and the Max Planck Institute for the History of Science, Berlin.

She has a BA in Liberal Arts (philosophy/mathematics, St John's College, Santa Fe, NM), MA degrees in philosophy and bioethics, and a PhD in the history and philosophy of science, all from the U. of Pittsburgh, PA. In 2006 she graduated with the degree of MA in gastronomy (U. of Adelaide) after completing a dissertation on celebratory food habits among Italo-Australian and Italian-American immigrants. Prior to joining the U. of Adelaide in 2006, she was director and lecturer/senior lecturer in the Unit for History and Philosophy of Science at the U. of Sydney from 2000.

In the history and philosophy of science, Dr. Ankeny's research focuses on the roles of models and case-based reasoning in science, model organisms, the philosophy of medicine, and the history of contemporary life sciences. Her research in bioethics examines ethical and policy issues in genetics, reproduction, women's health, transplantation, and embryo and stem cell research, among other topics.She also has expertise and ongoing research on health and science policy, particularly regarding public engagement. She holds (together with Bob Cook-Deegan) a US Studies Centre grant (2011) to examine the history and implications of the Bermuda principles for genomic data sharing, as well as a NETS small grant to examine Australian public attitudes toward synthetic biology. She is also the lead investigator on an Australian Research Council Linkage Project grant entitled "Hostel Stories: Toward a Richer Narrative of the Lived Experiences of Migrants" (2012-14) in collaboration with the Migration Museum.

Eric Werner

Department of Computer Science, and Department of Physiology, Anatomy and Genetics
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Local and Global Control in Development and Evolution

How can a single fertilized egg develop into a bilaterally symmetric organism? How is this related to gynandromorphs (organisms that are half male and half female)? How do stem cells work? How are they related to cancer stem cells and cancer metastases? Can all cancers be unified and understood in a general theoretical framework? Developmental control theory, I will argue, can explain very diverse phenomena. The challenge is how to relate lower levels of molecular implementation with abstract theories of developmental control networks. Data gains meaning, sense, and relevance only in the light of a theoretical perspective. I will address the interplay between experimental data and meaning by giving concrete examples from developmental systems biology.

Selected Publications

(2012) The Selected Papers of Denis Noble CBE FRS (ed., with D. Noble, Z. Chen. And C. Auffray). Imperial College Press.

(2009) Evolutionary embryos. Nature 460: 35-36.

(2009) What genetic changes made us uniquely human? Or why aren't we mice?" PLoS Biol 7(5): e1000112.

(2007) How central is the genome?" Science 317: 753-754

(2007) Really new advances: RNA control and developmental systems biology. Economist (London), July 2.

(2007) All systems go. Nature 446: 493-494.

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(2003) Systems biology unplugged. Drug Discov Today 8: 250-252.

(2002) Systems biology: The new darling of drug discovery? Drug Discov Today 7: 947-949.

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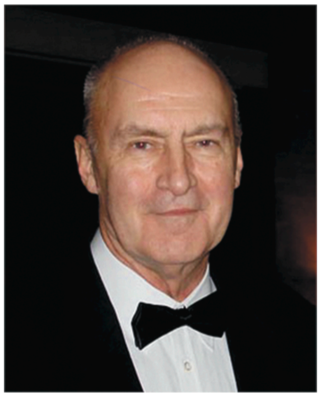

Biographical note

Dr. Eric Werner currently holds positions at the Balliol Graduate Centre, Oxford Advanced Research Foundation, in the departments of Computer Science, and of Physiology, Anatomy and Genetics, at the U. of Oxford, and at Cellnomica, Inc. He is the President of the Oxford Advanced Research Foundation.

His research themes include mathematics, logic, and computer science (logic of ability, logic of information, time dependent modal logics, logic of games). He is one of the founders of Distributed AI (intelligent agents and multi-agent systems, distributed robots). Other interests include the theory of communication and cooperation (agents, robots, animals, cells), cells as communicating social agents, systems biology (conceptual foundations, early embryo development, cancer), and software development for *in silico* dynamic multi-cellular systems biology.

He has been a researcher at GSF, the German National Research Center for Environment and Health, and the U. of Munich; at INRIA, the French National Research Institute for Computer Science; at CNR, the Italian National Research Center in Rome; at AAII, the Australian Artificial Intelligence Institute (SRI), in Melbourne; at SONY Research Labs in Tokyo; and at the universities of Hamburg and Ibadan, Nigeria.

Joachim Schummer

Hyle, International Journal for Philosophy of Chemistry, Berlin
http://www.hyle.org/

Knowing through Making: From Synthetic Chemistry to Synthetic Biology

The recently emerged synthetic biology differs from received biotechnologies such as genetic or metabolic engineering by emphasizing the creation of living beings rather than their mere modification. Apart from the technological use of the products, it is promised that the creation will also improve our basic understanding of life. Various epistemic claims have been made that revive the clas-sical *verum factum* principle: from bold claims such as "What I cannot build, I cannot understand" to more modest statements according to which the cre-ation of living beings brings about some important understanding. Such claims are frequently justified by the analogy between today's synthetic biology and 19th-century synthetic chemistry.

I will scrutinize both the epistemic claim of synthetic biology and its analogy to synthetic chemistry. I will do so by first reconsidering the *verum factum* principle in philosophy and its various well-known applications to 19th-century synthetic chemistry, which requires a historical and methodological analysis of chemical structure theory. By exploring the analogy to synthetic biology, I will argue that essential features are missing here, such that it is difficult to uphold the *verum factum* principle other than in its trivial form. Moreover, because synthetic biology explicitly gives up traditional epistemic goals in order to distinguish itself from established fields, its epistemic ambition becomes questionable.

Selected Publications

(2011) Das Gotteshandwerk: Die künstliche Herstellung von Leben im Labor. Berlin: Suhrkamp.

(2009) The creation of life in cultural context: From spontaneous generation to synthetic biology. In: The Ethics of Protocells: Moral and Social Implications of Creating Life in the Laboratory (Bedau M, Parke E, eds), 125-142. MIT Press.

(2009) Nanotechnologie: Spiele mit Grenzen. Frankfurt a. M.: Suhrkamp.

(1996) Philosophie der Chemie. Bestandsaufnahme und Ausblick (editor, with Psarros N, Ruthenberg K). Königshausen & Neumann.

Biographical note

Joachim Schummer has been the editor-in-chief of *HYLE: International Journal for Philosophy of Chemistry* since 1995, and serves on various international committees, including the UNESCO expert group on Nanotechnology and Ethics. He studied chemistry, philosophy, and history of art at the U. of Bonn (1982-85), and chemistry, philosophy, and sociology at the U. of Karlsruhe, where he graduated both in chemistry and philosophy and received his PhD (1994) and Habilitation (2002) in philosophy. Dr. Schummer has held teaching and research positions at the universities of Bielefeld, Darmstadt (Heisenberg Fellow), Hannover, Karlsruhe, Sofia, South Carolina (Columbia, SC), and the Australian National University (Canberra), the U. of Santo Tomas, Manila, and the U. Federal do Rio de Janeiro. His research interests focus on the history, philosophy, sociology, and ethics of science and technology, with emphasis on chemistry and nanotechnology.

Location and time

The focal symposium is held in **Hörsaal 2, UZA 1**, Biozentrum, Althanstrasse 14, Wien IX., on **Thursday 14 June, 3:00-6:45 p.m.**

A follow-up discussion with the speakers takes place at the Konrad Lorenz Institute for Evolution and Cognition Research (**KLI**), Adolf-Lorenz-Gasse 2, 3422 Altenberg, **the next day, 10:15-12:00 a.m.**

The KLI can easily be reached by train: The S40 (in the direction of Tulln) leaves Wien Franz-Josefs-Bahnhof at **9.02** and **9.32 a.m.** The ride to Greifenstein/Altenberg takes 28 minutes. Upon leaving the station, take a right turn and walk for about 8 minutes until you reach a wooden chapel. At that crossing, the KLI, which is located in the Lorenz mansion, can be seen across the street.

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