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## Review 2016 and Structure of the KLI



*The KLI combines integrative theoretical enterprises, interdisciplinary workshops, and international vision in an inspired setting, adapted to become a veritable scholar's paradise.*

*D. Kimbrough Oller  
(University of Memphis)*

## 1.1 The Year in Review

The year 2016 was a year of bustling activity and outstanding events, making full use of the exquisite facilities of the new KLI building in Klosterneuburg. We hosted the 33<sup>rd</sup> Altenberg Workshop in Theoretical Biology on the topic of “Convergent Evolution in Stone-Tool Technology” as well as the 4<sup>th</sup> European Seminar in the Philosophy of the Life Sciences on “Function and Malfunction in the Biological, Biomedical, and Social Sciences,” the well-established summerschool co-organized by the University of Exeter, IHPST Paris-1 Sorbonne, University of the Basque Country, Leibniz University of Hannover, University of Geneva, and the KLI. Besides these traditional formats, the 1<sup>st</sup> KLI Science Forum was dedicated to the discussion of “Two Sides of the Same Coin: Mechanistic and Population-Level Perspectives on Evolution.” In addition, several cooperative events were organized, one joint workshop with the Wissenschaftskolleg zu Berlin and two collaborative workshops with the Complexity Science Hub of the Medical University of Vienna. 40 KLI Colloquia were given either by KLI fellows or external speakers. The KLI also extended its outreach activities by participating in public events such as the “Long Night of Research,” the “Science Fair,” and the “Klosterneuburger Höfefest” informing the public about the KLI’s mission and research activities. Moreover, a professional filmmaker, Greg Boyle, created a KLI image video and short portraits of several KLI fellows, now accessible via the KLI homepage on a newly created KLI YouTube channel. A new line of activities dedicated to “Arts & Science” makes use of the exhibition spaces available at the new KLI and hosted artists such as Petra Maitz, Felix Scholz, and Gemma Anderson as well as the composer Franz J. Mach to present and discuss their work in a scientific environment.

Over the course of the year 2016 we enjoyed a thriving community of 24 interdisciplinary fellows at the institute. The fellows and staff of the KLI published 20 books and articles and four issues of the journal *Biological Theory*, and gave 61 scientific presentations at international meetings. A new book appeared as part of the Vienna Series in Theoretical Biology entitled “Multicellularity: Origins and Evolution” which derived from the 31<sup>st</sup> Altenberg Workshop in Theoretical Biology hosted by the KLI in 2014. Multiple international symposia and conferences were attended by KLI fellows and staff, such as the 6<sup>th</sup> Meeting of the European Society of Evolutionary Developmental Biology in Uppsala.

For the possibility to pursue our endeavors and providing an enabling environment for scholars and young researchers, we are much obliged to the members of the KLI Trust, the Board of Directors, the Scientific Advisory Board, as well as the staff and fellows of the KLI, and, above all, to Traudl Engelhorn for her generous support.

Gerd B. Müller  
President

## 1.2 The KLI



- 4 The KLI is an international center for Theoretical Biology. The institute commits itself to the formulation, analysis, and integration of biological theories as well as the investigation of their scientific and cultural consequences. The thematic focus is on evolutionary biology, developmental biology, and cognition. The KLI supports interdisciplinary research projects in these areas that aim at generating models of living systems or meta-theoretical constructions of historical, philosophical, or cultural aspects of biological theories. Research at the KLI is supported by fellowships in five different categories; granting decisions are based on international peer review.

The KLI also pursues its objectives by organizing international workshops, summer schools, and colloquia, and by publishing a scientific journal and a book series.

## 1.3 Organization of the KLI

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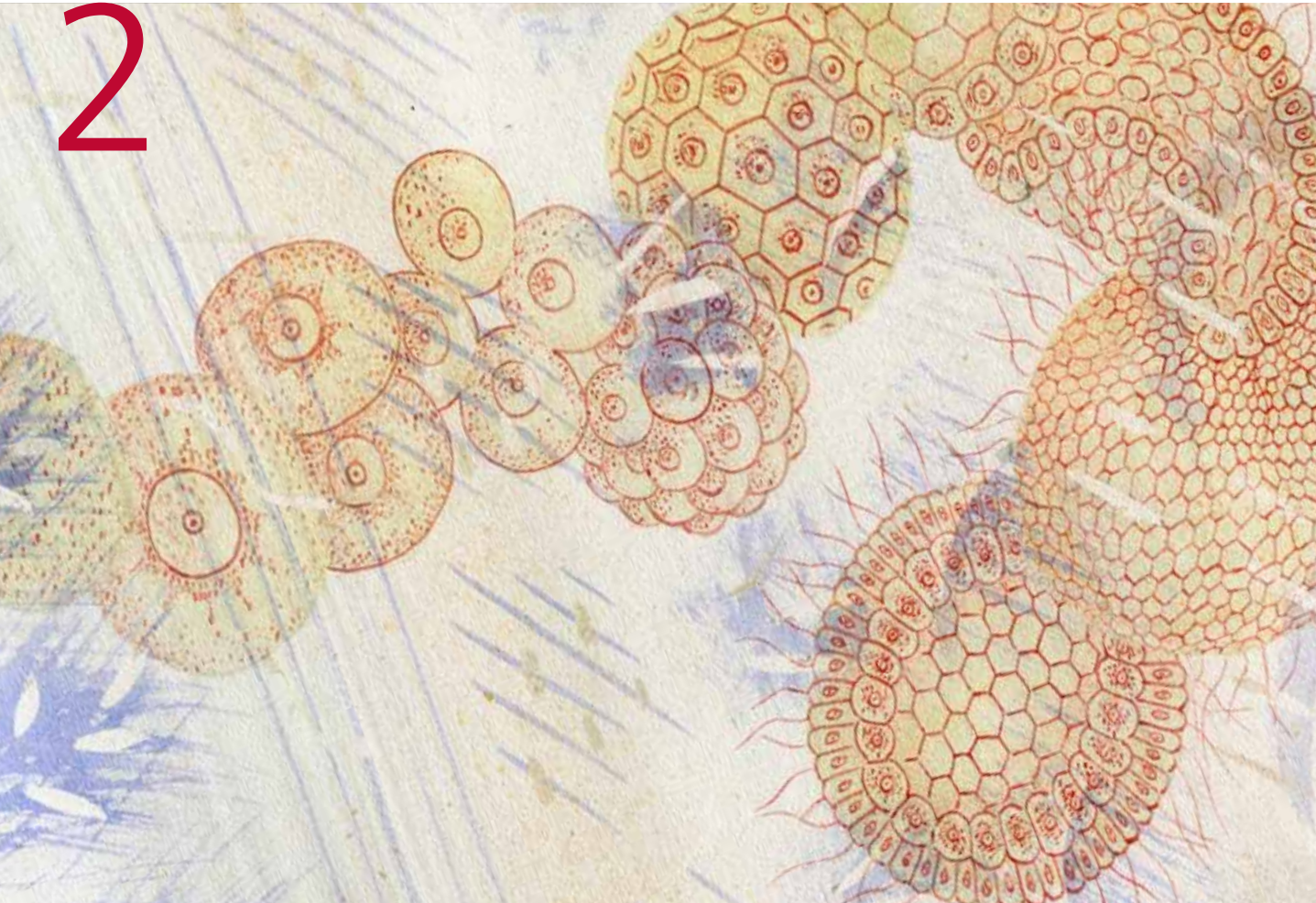
### **External Faculty**

PROF. DR. WALTER FONTANA  
Department of Systems Biology, Harvard Medical School,  
Boston, MA  
PROF. DR. MANFRED LAUBICHLER  
Department of Biology, Arizona State University, Tempe, AZ;  
Max Planck Institute for the History of Science, Berlin  
PROF. DR. STUART NEWMAN  
Department of Cell Biology and Anatomy, New York Medical College,  
Valhalla, NY  
PROF. DR. D. KIMBROUGH OLLER  
School of Audiology and Speech-Language Pathology,  
University of Memphis, TN



## Scientific Projects

# 2



*The KLI offers different types of fellowships for students, post-docs, and visiting scientists or scholars in the area of theoretical biology for a period of a few weeks up to two years. All project applications are subjected to an international review process.*

## 2.1 Applications

In 2016, the KLI received a total of 30 applications for fellowships, 18 of these were granted for 2016 or 2017, achieving an overall acceptance rate of 60% .

## 2.2 Writing-Up Fellowships

### **Chiara Elettra FERRARIO**

(October 2015 – March 2016)



*Chiara holds a Master's degree from the University of Milan and has been working on her PhD thesis "The Evolutionary Role of Imitation in the Hominid Lineage: Time for a Reappraisal" at the Victoria University of Wellington, New Zealand as well as at the Australian National University, Canberra. Having received a Writing-Up Fellowship from the KLI she is currently completing her PhD thesis.*

### **The Role of Imitation in Hominid Evolution: Time for a Reappraisal**

Both humans and nonhuman animals have culture, but human culture is different in fundamental ways. Human culture has often been characterized as "cumulative" for its peculiar tendency to accumulate modifications in a seemingly irreversible manner over time (a property that we all exploit "standing on the shoulders of giants" with Google Scholar). Complex adaptations such as language, institutions, art, religions, but also technology and science, from its simplest (think stone artifacts or ancient trigonometry) to most complex forms (think spacecrafts or quantum theory), can be explained by the extraordinary human capacity to faithfully transmit progressive achievements through generations. New additions serve as platforms for further improvements, so that complexity increases steadily. The so-called ratchet hypothesis

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intriguingly suggests that this process might be due to the special high-fidelity properties of imitation, a social learning mechanism exclusively found in humans – so the argument went. This scenario has undergone a series of challenges in recent years, perhaps the most relevant being the extent to which imitative capacities have been retrieved in nonhuman animals. Nonetheless, it continues to exert a singular influence on the field of cultural evolution. In my work, I look at how new evidence and methodology recently emerged in cultural evolution and social learning studies can be put at work to offer a meaningful re-evaluation of the “ratchet argument.”



### **Ivan Dario GONZALEZ CABRERA**

(January 2016 – July 2016)

*Ivan Dario Gonzalez Cabrera is a PhD Student at the School of Philosophy at the Australian National University, Canberra and a Visiting Fellow at the Department of Comparative and Developmental Psychology at the Max Planck Institute for Evolutionary Anthropology in Leipzig. He has recently received a Writing-Up Fellowship to work on his project at the KLI.*

### **Towards a Comprehensive Theory of Normative Cognition**

The topic of my PhD thesis is the evolution of normative cognition. More specifically, I am interested in evolution, development, and cognitive architecture behind our distinctive capacity for normative guidance, and how traditional debates in moral philosophy can be advanced and transformed by theories and findings in empirical sciences such as evolutionary and developmental biology, comparative and developmental psychology, cognitive science, and social neuroscience. Broadly construed, normative guidance refers to our distinctive capacity to grasp norms and to make normative judgments (see Gibbard, 1990; Kitcher, 2011; Sripada & Stich, 2007). This includes the development and understanding of moral



emotions such as shame and guilt, the emergence of skills of joint intentionality, the nature of empathy and sympathy, as well as other mechanisms that support pro-social behavior and the enforcement of social norms.

My thesis is divided into three main parts. In the first part, building mainly on the work of Sterelny (2003, 2010), Kitcher (2011), Boehm (1999, 2012), I address questions concerning the evolution of normative guidance. In the second part, following the work of Tomasello and colleagues (Tomasello, Melis, Tennie, Wyman, & Herrmann, 2012; Tomasello & Vaish, 2013; Vaish & Tomasello, 2013), I focus on issues around the ontogeny of this capacity. In the third part, I tackle questions related to the cognitive architecture of normative cognition by framing them within a hierarchical view of human cognition akin to dual process frameworks of moral psychology (Greene, 2008; Greene, Morelli, Lowenberg, Nystrom, & Cohen, 2008; Greene, Nystrom, Engell, Darley, & Cohen, 2004; Greene, Sommerville, Nystrom, Darley, & Cohen, 2001; Mallon & Nichols, 2011; Sripada & Stich, 2007), but not restricted to them (Daw, Gershman, Seymour, Dayan, & Dolan, 2011; Doll, Jacobs, Sanfey, & Frank, 2009; Fermin, Yoshida, Ito, Yoshimoto, & Doya, 2010; Gershman, Markman, & Otto, 2014; Glascher, Daw, Dayan, & O'Doherty, 2010; Otto, Gershman, Markman, & Daw, 2013; Simon & Daw, 2011; Wunderlich, Dayan, et al., 2012; Wunderlich, Smittenaar, & Dolan, 2012).

### **Sara MURILLO SÁNCHEZ**

(October 2016 – March 2017)

*Sara Sara Murillo Sánchez is a PhD student at the Department of Logic and Philosophy of Science IAS-Research Group of the University of the Basque Country, San Sebastián. She has been awarded a KLI Writing-Up Fellowship to complete her thesis*





*"About the Naturalization of the Concepts of Autonomy, Function and Agency in an Empirical-Theoretical Approach to the Origin of Minimal Cellular Systems."*

### **A "Systems Chemistry" Approach for the Naturalization of Concepts in Biology**

The understanding of the phenomenon of life has been always a main challenge for science. Traditionally, the evolutionary framework, in which life is conceived from a historical and collective point of view, has had higher weight; however, the organizational perspective, which looks for general principles underlying biological individuals (cellular organisms in particular), is gaining momentum during the last years, especially after the emergence of systems biology. This tension is also apparent within the origins of the life research field, where there are very important difficulties to account for the transition from the chemical (molecular) to the biological (cellular) domain according to a classical evolutionary scenario (i.e., selection algorithms applied to populations of 'replicating' chemical species). In this context, a new sub-discipline has been launched recently in Europe, called 'systems chemistry,' whose aim is the scientific study of complex mixtures of molecules and their emergent (dynamic and evolutionary) behaviors, which could change the state of affairs, providing the right platform to tackle the origin-of-life problem. This PhD is an attempt to contribute to that general goal, showing that there is very interesting and fertile ground to explore various connections between systems biology and systems chemistry. More precisely, my claim is that fundamental concepts in biological explanations, like function or information, which have an intrinsic relational character (i.e., ought to be understood in terms of relationships among molecular components), should be naturalized through a genealogical approach to biological complexity, starting from its chemical roots. In other words, I will defend that origins-of-life research, if tackled from a systems standpoint (like systems chemistry aims to do), is bound to provide key insights for theoretical biology, both from an organizational and an evolutionary perspective. I

have worked in the development of an empirical protocellular model that may bring some light into several aspects related to the emergence of cellular organization.

Through that experimental model, my objective is to illustrate how the first steps towards biological individuality and function could be addressed in a chemical context. In addition, on more general grounds, this PhD is an appeal to transdisciplinarity in science. In fact, the experimental work carried out was designed from a previous theoretical model, which in turn was based on philosophical reflection around the problem of origins of life. On these lines, we will claim that philosophical work, if properly channeled, can reinforce science and vice-versa. This leads to a new conception of philosophy of science (philosophy for science), which will be suggested as the most promising option for philosophy to play a relevant role in the future generation of human knowledge.

### **Celeste PEREZ BEN**

(June 2016 – November 2016)

*Celeste Pérez Ben is a PhD candidate in Faculty of Exact and Natural Sciences of the University of Buenos Aires. She has received a Writing-Up Fellowship of the KLI to complete her PhD thesis.*



### **Miniaturization, Heterochrony, and Morphology: A Paleobiological Approach**

Miniaturization is a phylogenetic concept, which has been defined as the evolution of extremely small adult size in a lineage. The effects of miniaturization at the organismic level extend to all biological aspects, from physiological changes to ecological and ethological ones. With regard to morphological consequences, miniaturization does not simply imply the decrease of the body size of the adult; it usually results from complex modifications of the presumed ancestral ontogenetic

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trajectory as well as structural modifications to maintain functional efficiency. However, the actual mechanism that leads to a strikingly diminished adult size may vary in each taxon.

This evolutionary phenomenon has been proposed as a key factor for the phyletic diversification above the species level and the evolution of major clades, which is consistent with three phenomena of potential significance as sources of morphological diversity that have been documented in miniaturized taxa: 1) increased intraspecific variation, 2) simplification and structural reduction, and 3) morphological novelties. Among vertebrates, miniaturization has been considered as a factor involved in the origin of living amphibians, amniotes, snakes and lizards. Particularly, current phylogenetic hypotheses place the Paleozoic miniaturized temnospondyl amphibians as the closest relatives of frogs and salamanders, indicating that miniaturization could have played an important role in the origin of these extant groups. For my doctoral dissertation, I seek to recognize the potential micro- and macroevolutionary effects of miniaturization in temnospondyl amphibians and to investigate the ontogenetic heterochronies that led to a decrease of body size in this group. It is expected that the study of the impact of miniaturization in temnospondyls will shed light on our understanding of this significant evolutionary phenomenon, and its role in the origin of living amphibians.



### **André STRAUSS**

(April 2016 – August 2016)

*André Strauss holds a Bachelor's degree in Anthropology and Geology, and a Master's degree in Evolutionary Biology. He is a PhD student at the Max Planck Institute for Evolutionary Anthropology under the supervision of Philipp Gunz. He was awarded a KLI Writing-Up Fellowship to complete his PhD thesis.*

## Late Juvenile, Early Adult Cranial Growth in Hominids: Implications for the Origin of the Genus Homo

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The emergence of the genus *Homo* is a key moment in human evolution. From 2 Myr ago the *Homo* lineage is documented by an increasingly rich fossil record, but the earliest phase remains poorly understood and the ancestral taxon elusive. Recently the newly discovered species *Australopithecus sediba* from southern Africa has been proposed as the direct ancestor of the *Homo* lineage, in particular based on cranial features of the holotype. This type specimen MH1 is a juvenile, but the diagnostic morphology was assumed to be unaffected by late growth into adulthood. As part of my PhD project, I developed a new geometric morphometric protocol that can cope with the cranial morphological variation ranging from infant humans to adult crested gorillas. This new protocol is not only based on a high-density coverage of landmarks but also allows overlapping lines and surfaces to be analyzed concomitantly. Based on this protocol we present a 3D geometric morphometric assessment of the MH1 cranium to assess the estimated adult form of the specimen, and its implications for the proposed ancestry of *A. sediba* to the genus *Homo*. Using an ontogenetic comparative database composed by 243 crania of hominins and great apes we show that MH1 shares an ontogenetic trajectory with *A. africanus* supporting its initial classification in that genus. Phenetic analysis show a strong association of MH1 and Sts 52. When the adult morphology of both fossils is predicted using extant hominoids as a model they become significantly more similar to, but still more gracile than, mature *A. africanus* (Sts 5 and Sts 71). When the same developmental simulation is applied to Taung the specimen fails to cluster with Sts 5 and Sts 71, becoming similar to the adult predictions of MH 1 and Sts 52. An important conclusion is that, by itself, cranial gracilization within an australopithecus ontogenetic trajectory does not lead to a *Homo* like morphology. In this frame the cranial morphology of MH1 suits better in the broader debate of specific diversity within the South Africa *Australopithecus* genus than to the issue of the emergence of the genus *Homo*. Together with the chrono-





logy for the appearance of the genus *Homo* our findings make unlikely that *A. sediba* is a direct ancestral to it and highlights the importance of taking late changes of growth in consideration before taxonomic assessments are made.



### **Zsóka Anna VÁSÁRHELYI**

(March 2016 – September 2016)

*Zsóka Vásárhelyi holds a BSc and Master's degree in Biology from the Eötvös Lóránd University, Budapest. She is doing her PhD thesis in the Theoretical Evolutionary Biology Doctoral Program of the Eötvös Lóránd University under the supervision of István Scheuring. Zsóka Vásárhelyi has been awarded a KLI Writing-Up Fellowship to complete her thesis.*

### **The Human Personality Diversification: Evolutionary Models and Hypotheses**

The human personality shows a striking diversity around the world. But when, how and why did this diversity evolve? In my PhD thesis, I intend to present a general hypothesis and simulated models that could help us answer the above questions. My main contribution is a theoretical one: the agricultural trigger hypothesis states that the last and perhaps biggest explosion of personality diversification happened along the Neolithic Transition. The line of changes that accompanied the appearance of agricultural societies, like sedentary life, bigger settlements, hierarchy, and society-wide social division of labour, all acted as to enhance behavioral diversification. While in small and mobile pre-agricultural bands specialization and extraordinary personality types were most likely to be counterselected, in the present civilization these could mean a significant selective advantage. The transition between the two selective environments probably happened hand in hand with the appearance of fully agrarian societies and the diversification of personality continues still then. The whole process of personality diversification is far too complex to study as a

whole, but certain subprocess of it, like the appearance of heritable specialization by social division of labour or a change in the selective environment, I modelled by computer simulations. Thus far I have the above results to include into my PhD thesis, and I plan to complete the work with a multilevel selection model about how the within and between group selective process contributed to the transition.

### **Berta VERD**

(November 2015 – April 2016)



*Berta holds a Bachelor's degree in Mathematics from Polytechnic University of Catalonia (UPC), Barcelona and Master's degrees from Kings College as well as Imperial College, London. She worked on her PhD thesis at the Centre for Genomic Regulation at the Pompeu Fabra University, Barcelona and at the Wissenschaftskolleg zu Berlin. Berta was a Writing-Up Fellow at the KLI where she completed her PhD thesis. She is now a Postdoctoral Fellows at the KLI (see 2.3)*

### **Evolution of Different Dynamic Modes of Segmentation**

My PhD project studies the evolution of developmental systems. As a case study, we are looking at the gap gene network involved in pattern formation and segment determination during early insect development. My approach focuses on understanding the dynamics implemented by this system and how they constrain, and guide the evolution of developmental patterning processes. During my project, I have used methods from dynamical systems theory – in particular the geometrical analysis of configuration space – to characterize gap gene regulation in *Drosophila melanogaster*. My analysis reveals a damped oscillator mechanism that underlies the dynamic expression of posterior gap domains. This is a very suprising finding in a long-germband insect, which forms its segments simultaneously, and is similar in kind to the oscillatory mecha-

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nism producing segments sequentially in short-germ-band embryos. I am currently extending my analysis to characterize the dynamic mechanisms underlying pattern formation by the gap genes in two more species of flies (*Megaselia abdita* and *Clogmia albipunctata*). My work raises fundamental questions concerning the evolution of evolving dynamical systems.

## 2.3 Postdoctoral Fellowships



### **Wesley Herb ANDERSON**

(July 2016 – August 2017)

*Wesley Herb Anderson holds a Bachelor's degree in Philosophy from Portland State University and a Master's degree in Philosophy from The University of Wisconsin, Milwaukee. He completed his PhD in History and Philosophy of Science at Arizona State University, Tempe. His PhD thesis was on "Advancing the Causal Theory of Natural Selection: Theory and Methodology" under the supervision of Brad Armendt.*

### **Demography, Causal Structure, Evolutionary Dynamics, and Novelties**

The goal of the project is two-fold. First, I aim to provide the conceptual resources necessary for thinking about novelties that arise from niche construction and phenotypic plasticity. The Modern Synthesis provides no such framework. In particular, insofar as novelties are understood as a subset of adaptations where the trait was non-homologous in the lineage before fixation, then no conceptual sense can be made of novelties arising from niche construction or phenotypic plasticity. This is because the traditional account of adaptation assumes the trait evolved in a common environment, which is unlikely in either the case of niche construction or phenotypic plasticity.

Second, I aim to develop the formalization necessary for analyzing the evolutionary dynamics of systems undergoing niche construction and phenotypic plasticity (i) when demographic conditions are being constructed by traits or causing traits to develop and (ii) when both offspring dispersal and frequency-dependent selection are local only. We currently have no agreed upon machinery for doing so. Moreover most work on niche construction and phenotypic plasticity assume that offspring dispersal is always global. Of primary interest in this work is whether the causal direction between traits and demographic conditions will change the evolutionary dynamics in interesting ways, and whether global or local dispersal and frequency-dependent selection favor the evolution of different kinds of novelties—thus revealing demographic features of mechanisms of innovation.

In short, the project is in line with theoretical work on The Extended Synthesis at the intersection of philosophy of evolutionary biology and mathematical evolutionary biology.

### **Argyris ARNELLOS**

(November 2013 – July 2016)

*Argyris Arnellos was a Marie Curie Postdoctoral Fellow at the IAS-Research Centre for Life, Mind and Society (Department of Logic and Philosophy of Science, University of the Basque Country). Previously, he was a researcher and lecturer in the Department of Product and Systems Design Engineering at the University of the Aegean in Syros, Greece. His current line of research is centered on the role of the notion of autonomy in integrating constitutive and interactive aspects of multicellular organisms, with a focus on developmental regulatory mechanisms and their role in the self-construction of multicellular organizations, and in the formation of complex body plans and their resulting behaviors. His PhD was on "The Emergence of Meaning in Autonomous Agents and in Artificial Environments."*





*He has published in several scientific journals and participated in numerous international and national conferences in the areas of autonomous and complex systems, 2<sup>nd</sup>-order cybernetics, philosophy of biology, philosophy of mind, and interactivism, design theory, artificial intelligence, and human-computer Interaction.*

### **Organizational Requirements and Regulation for Organismal Development and Maintenance**

From an organizational perspective, organisms have the capacity to regulate and modify both their developmental processes and their interactions with the environment, while at the same time they are able to incorporate influences of the environment in their developmental and self-maintaining dynamics. They achieve this by exhibiting a developmental organization that fosters the endogenous construction of complex patterns of its own regulation, and which is brought about by the interplay between genetic, epigenetic, interactive, and environmental factors at the cellular, tissue and organismal levels. Several difficulties appear when one tries to specify the organizational conditions and the terms in which the development and maintenance of such an organization and its evolutionary characteristics should be accounted for. The main objective of this research project is to elucidate and provide a feasible explanation of the overall relation between the developmental organization and its endogenously produced regulation in multicellular organisms. More specifically, this project aims at getting a better understanding of:

(1) the nature, form, and pattern of different types of developmental regulatory mechanisms in an organism; (2) the ways developmental regulation shapes the relation between cells (parts), groups of cells (tissues), and the organisms (wholes) in which they participate; (3) whether the concept of regulation (and which specific regulatory patterns) can be theoretically established as a general principle underlying the exportation of "organismality" from the unicellular to a meta-cellular level; (4) how the nervous system and the respective interactive and environmental regulatory factors



contribute, influence, and transform the overall pattern for the regulation of development and maintenance; (5) the regulatory logic that allows for new forms of complex agency and flexible behavior.

### **Riana June BETZLER**

(September 2016 – August 2016)



*Riana Betzler holds a Bachelor's degree in Psychology from Yale University, New Haven, CT. She studied at the European College of Liberal Arts in Berlin and did her Master's Degree in Philosophy on "The Multiple Meanings of Mechanisms: A Challenge for the New Mechanist Philosophy" at University of Cambridge, UK. Her PhD thesis "What is Empathy and Is it Valuable?" was done under the supervision of Tim Lewens at University of Cambridge, UK.*

### **Genealogical Approaches and the Origins of Empathy**

In my postdoctoral research at the KLI, I aim to undertake two tasks. First, I seek to investigate the method of genealogy broadly considered. Second, I aim to apply a sophisticated evolutionary genealogical approach to the case of empathy. In the first part of my project, I seek to understand how various genealogical approaches—in particular philosophical genealogies as exemplified by Williams (2002) and Craig (1990), traditional evolutionary genealogies, and cultural evolutionary genealogies, as exemplified by the Heyes (2014), Sterelny (2003), and Richerson & Boyd (2005)—relate to one another. How similar are their methodologies? What are the differences between them? What might these various forms of genealogy, which look different on the surface, be able to contribute to one another? Can they be combined fruitfully? In the second part of my project, I aim to provide a sophisticated genealogical approach to empathy that brings together insights from the history of empathy as a human value (philosophical



genealogy), cultural evolution, and more traditional biological evolutionary approaches. There is good reason to look to empathy as fertile ground for such an approach because it has important connections with other traits and capacities that have been the subject of cultural evolutionary explorations, including mindreading, psychopathy, and cooperation. I hope that this sophisticated genealogical approach to empathy may help to provide the basis for a mature evolutionary approach to the emotions more broadly.



### **Daniel BROOKS**

(October 2015 – September 2017)

*Daniel Brooks holds Bachelor's degrees in Philosophy and German Studies from the University of Cincinnati and a Master's degree in Philosophy from Bielefeld University. In 2014 he completed his PhD studies in Bielefeld under his dissertation project "The Concept of Levels of Organization in Biology." Before his Postdoctoral Fellowship at the KLI, Daniel taught graduate and undergraduate seminars in current topics in the philosophy of science and epistemology at the University of Münster.*

### **The Role of Levels of Organization in Biological Thought**

My research project will focus on analyzing the role of "levels of organization" in scientific reasoning about explanation in biology. The concept of "levels" evokes a hierarchical image of the world that is vertically stratified into a graduated continuity: The things found at one horizontal slice of the world somehow "make up" or "are continuous with" things found at another slice, and so on. Yet, despite its ubiquity, "levels" remains a decisively ambiguous concept in biology. The "things" that constitute the horizontal image of the world can vary widely between different contexts. Sometimes they refer to real objects, like part-whole compositional relationships, or they can refer to epistemic units, such as the "level

of genetics” or “level of ecology.” In my dissertation, I showed that this variability reveals usage of “levels” in science to be governed mostly by its intuitive appeal, whose justification is based on context-dependent criteria of adequacy. Far from useless, however, “levels” instead exemplifies what one philosopher calls “productive ambiguity” of open-ended helping concepts in science. For this reason, philosophical analyses should abandon attempts to unify different uses of “levels” and acknowledge the fragmentary character of the concept.

This research project will expand on this foundation by explicating two distinct roles attributed to the concept of “levels” in different arenas of scientific reasoning concerning explanation. One of these roles is pedagogical, and is often encountered in introductory textbooks to biology, such as the Campbell Biology series, where “levels” is used to introduce the major unifying themes of the field. Another role is organizational, and is encountered in professional research literature of working scientists, in particular review articles and commentaries on the state of research in a certain area of investigation. Here “levels” is often used by scientists as a theoretical device with which to navigate within complex phenomena distributed across multiple levels, or to coordinate interdisciplinary efforts for investigating such phenomena that cannot be adequately addressed by any one of the involved disciplines alone. Though distinct, these roles complement one another in biological reasoning, albeit in starkly different contexts of scientific practice.

To conduct this analysis I will focus on two case studies from science in which levels are prominently used in both of the roles specified above. The first, macromolecular structure, is treated in a well-defined local manner, focusing on features of (some) macromolecules such as nucleic acid and proteins (but, tellingly, not lipids or sugars). The second, the nervous system, is treated in a more open-ended general manner, owing to the vast complexity of neural phenomena that “levels” is used to investigate.



### **James DiFRISCO**

(October 2015 – September 2017)

*James DiFRISCO received his PhD in Philosophy from University of Leuven, Belgium, with a dissertation entitled "Process and Levels of Organization: A Dynamic Ontology for the Life Sciences." His research focuses on problems related to biological organization, functions, individuality, and levels, as well as on a variety of themes in naturalistic metaphysics including physicalism and the relations between scientific domains.*

### **Hierarchy and Individuality**

According to ordinary intuition, living individuals and organisms are the same thing. Developments in the life sciences, however, have indicated that familiar organisms are just one case of individuality among others, including genes, cells, colonies, groups, species, and even ecosystems. It has therefore become a problem to explain what it is, in general, that makes something a biological individual. My project takes its point of departure from the insufficiency of evolutionary explanations currently on offer, in which being an individual roughly means being a unit of selection. Instead of opposing this by recourse to more physiological explanations of individuality, however, I suggest it will be more illuminating to integrate both within a more general hierarchical framework. I propose to do this by introducing into the discussion a dynamical or process-based view of both individuation and hierarchical organization. A dynamical perspective ensures that biological individuation is explained as an ongoing, evolving process. A hierarchical perspective is necessary for accommodating the fact there are different dynamics at different levels and scales that are causally responsible for individuating biological systems.

Carrying out this project will involve developing an alternative to the dominant approaches to biological hierarchy theory that relies on dynamical parameters and pervasive scalar properties of the living world. I also connect the

issues of biological individuality and hierarchy to wider concerns about the explanatory power of natural selection, problems with biological functionalism, and the relationships between biology and the other natural sciences.

**Barbara FISCHER**

(October 2015 – August 2018)



*Barbara Fischer studied at University College Cork, Ireland and University of Vienna where she graduated in Biomathematics. She made her PhD in Evolutionary Biology and Biomathematics at the University of Berne, Switzerland. She worked at the University of Helsinki, the University of Berne and at IIASA, Laxenburg/Austria. She has been a Postdoctoral Research Associate at the University of Oslo and a Researcher and Lecturer at the University of Vienna.*

**Evolvability and Integration of the Human Pelvis**

Compared to other primates, childbirth is remarkably difficult in humans because the head of a human neonate is large relative to the birth-relevant dimensions of the maternal pelvis. It seems puzzling that females have not evolved wider pelvises despite the high maternal mortality and morbidity risk connected to childbirth in humans. In the proposed project, I will build a comprehensive novel model of the evolution of the human pelvis. With this project, I will contribute to answering the question why this “obstetric dilemma” still exists in modern humans. Current models explaining the evolution of human pelvic dimensions, or the lack thereof, are based on verbal arguments only. In contrast, I propose to use empirical data on phenotypic variation of pelvic dimensions in human populations (data from populations in North America, Europe, and Southern Africa) as well as mathematical models of evolutionary dynamics (quantitative genetic models) that build on these data to quantitatively assess hypotheses on pelvis evolution. In





particular, I will estimate the phenotypic integration and evolvability of different pelvic shape features. In an earlier study, I have shown that evolution has produced covariances between pelvis shape and other body dimensions that contribute to ease childbirth. Based on these results, I will compare the variational properties of the pelvis across sexes and populations. I will devise a quantitative model of the constraints imposed upon the evolution of the human pelvis using the collected empirical data and data from the gynecological literature.



### **Berta VERD**

(May 2016 – August 2017)

*Berta Verd holds a Bachelor's degree in Mathematics from Polytechnic University of Catalonia (UPC), Barcelona and Master's degrees from Kings College as well as Imperial College, London. She worked on her PhD thesis at the Centre for Genomic Regulation at the Pompeu Fabra University, Barcelona and at the Wissenschaftskolleg zu Berlin. Berta has recently completed her PhD and is a Postdoctoral Fellow at the KLI.*

### **Evolving Developmental Processes**

During insect development, segments either form sequentially (short germ-band) or simultaneously (long germ-band). In depteran insects (flies, midges, and mosquitoes), where the long germ-band mode of segmentation is used, the gap genes are activated by maternal gradients and cross regulate each other to form the first zygotic regulatory layer of the segmentation gene hierarchy. A precise data-driven mathematical model revealed that two distinct dynamical regimes govern anterior and posterior trunk gap gene patterning in *Drosophila melanogaster*. Stationary domain boundaries in the anterior rely on multi-stability whilst the observed anterior shifts of

posterior gap gene domains can be explained as an emergent property of an underlying regulatory mechanism implementing a damped oscillator. Major features of both regimes are recovered by a three-gene motif embedded in the gap gene regulatory network. Interestingly, this sub-network, known as the AC/DC motif, can also sustain oscillations. Oscillations are not found in the gap gene system, but are characteristic of short germ-band segmentation, suggesting that both modes share more than previously thought. Studying the evolution of gene regulatory networks can help us understand how oscillations arise or cease, and this will shed some light on how long germ-band segmentation could have repeatedly and independently evolved from the ancestral short germ-band mode. In order to address the evolvability of segment determination dynamics, I propose the following three-part project. The first step will be to perform a comparative analysis of the dynamics of gap gene pattern formation using data-driven models of gap gene regulatory network in three species of dipteran flies (*Drosophila melanogaster*, *Megaselia abdita*, and *Clogmia albipunctata*) where gap gene expression order is conserved but dynamics differ. Next, I will characterize intermediate gap gene regulatory networks obtained from *in silico* evolutionary simulations where the gap gene network in the more basal species *C. albipunctata* has been used as the starting point. These first two parts will help us understand how different expression dynamics arise from different network architectures within the same dynamic mode of segmentation, as well as reveal how these evolutionary changes might be shaped. On a more theoretical level, I plan to explore how the evolutionary trajectories between both dynamic modes of segmentation are constrained in parameter space by considering the AC/DC circuit as a basic dynamical module driving segmentation processes.

## 2.4 Senior Fellowships



**Lee ALTENBERG**

(April 2014 – May 2016)

*Lee Altenberg is an evolutionary theoretician. He served most recently as Associate Professor in Information and Computer Sciences at the University of Hawaii at Manoa. He received his AB in Genetics with Prof. Glenys Thomson at the University of California, Berkeley, and his PhD in Biological Sciences with Prof. Marcus W. Feldman at Stanford University. His Postdoctoral Fellowships include Stanford University, North Carolina State University, and Duke University, and he served on the faculty of Duke University prior to the University of Hawaii at Manoa. Recently he was a long term visitor at the Mathematical Biosciences Institute at the Ohio State University, and a participant in the program on computational theories of evolution at the Simons Institute at UC Berkeley. He is an Associate Editor of the journal BioSystems, an Editorial Board member of the journal Genetic Programming and Evolvable Machines, and is a founding member of the Board of Directors of the International Society for Artificial Life. He is a member of the Scientific Advisory Board of the EU-funded project, Speed of Adaptation in Population Genetics and Evolutionary Computation (SAGE). He served on the Board of the Maui Classical Music Festival, and was the Chair of the Native Hawaiian Plant Society on Maui.*

### Evolution of Development by Natural Selection

My principal project at the KLI would be to establish a more comprehensive mathematical framework than currently exists for understanding the evolution of evolvability and robustness – a subject that despite its rapidly growing body of work remains piecemeal, and where a comprehensive treatment could, I believe, put the existing results in perspective and reveal new directions of inquiry. In particular I wish to focus on the relationship

between equilibrium and far-from-equilibrium dynamics and the variational properties that come along with these dynamics. My recent work has focused on the evolution of probabilities of transformation in near-equilibrium populations; the “reduction principle” manifest in this domain appears to also operate on magnitudes and directions of transformation in the form of canalization. The underlying mathematical unity found for transformation probabilities prompts one to ask whether this unity also extends to transformation magnitudes and directions. The most challenging area mathematically is far-from-equilibrium, but this is where the evolution of evolvability is mainly generated. Developing new theory for far-from-equilibrium dynamics will be a focus of this project. Specific topics include:

- The Theory of “Growth and Mixing”;
- The Evolution of Evolvability under Recurrent Environmental Variation;
- Thresholds between Evolvability and Robustness;
- Determinants for the Evolution of Mutational Robustness;
- A Complex Systems-based Quantitative Genetics.

### **Willem HORDIJK**

(March 2016 – April 2018)



*Willem Hordijk is a computer scientist working in the areas of computational biology and bioinformatics. He was a graduate fellow at the Santa Fe Institute for several years, after which he worked on many short-term research and computing projects all over the world. As an independent researcher/consultant he provides computational support to other scientists, while his own research focuses primarily on autocatalytic sets and the origin and organization of life.*

### **Title Autocatalytic Sets: The Origin and Organization of Life**

Life is a self-sustaining and self-regulating chemical reaction network. In other words, a living system continuously regene-



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rates its own components, in such a way that these components maintain and regulate the underlying reaction network that produced them. Autocatalytic sets are a formalization of this notion of life. An autocatalytic set is a reaction network in which each reaction is catalyzed by at least one of the molecules from the set itself, and each molecule can be produced from a suitable food source by using only reactions from the set itself. Autocatalytic sets are believed to have played an important role in the origin and early evolution of life.

My colleague Prof. Mike Steel and I have developed a formal framework known as RAF theory to detect and analyze autocatalytic sets in general reaction networks. We have shown that autocatalytic sets are highly likely to exist under a wide variety of realistic assumptions in simple computational models of chemical reaction networks, and that these sets usually have a rich hierarchical structure of smaller and smaller autocatalytic subsets, which is an important requirement for their possible evolution. Furthermore, we have shown that the formal framework can be successfully applied to real chemical and biological networks as well, and that autocatalytic sets indeed exist in such real networks.

However, there is still somewhat of a gap between theory and experiments on the emergence and further evolution of autocatalytic sets. In this project, I will continue and expand my research on autocatalytic sets, in particular in collaboration with experimental chemists, in an effort to close this gap.



## 2.5 Visiting Scientists

### George McGHEE

(May 2016 – July 2016)



*George McGhee is Distinguished Professor of Paleobiology at Rutgers University (Piscataway, New Jersey), where he is a member of the Geological Sciences, Ecology & Evolution, and Oceanography graduate faculties. He completed the Master's degree in Paleontology at the University of North Carolina at Chapel Hill, and the PhD at the University of Rochester, working under the direction of Professor David M. Raup. He conducted pre-doctoral research with Professor Adolf Seilacher's Konstruktionsmorphologie research group at the University of Tübingen, and following his doctoral work he has held the positions of Visiting Scientist at the Field Museum of Natural History (Chicago), Research Associate at the American Museum of Natural History (New York), and Visiting Professor at the University of Tübingen.*

*Dr. McGhee is the author of over 150 research publications, and 5 research books: 'The Late Devonian Mass Extinction'; 'When the Invasion of Land Failed: The Legacy of the Devonian Extinction'; and 'Theoretical Morphology: The Concept and Its Applications', all published by Columbia University Press (New York); 'The Geometry of Evolution: Adaptive Landscapes and Theoretical Morphospaces', published by Cambridge University Press (England); and 'Convergent Evolution: Limited Forms Most Beautiful', published by MIT in the Vienna Series in Theoretical Biology.*



## Convergent Evolution in the Oceans

My stay of research at the KLI in the Summer of 2010 enabled me to finish writing the book 'Convergent Evolution: Limited Forms Most Beautiful', which was subsequently published in the KLI's Vienna Series in Theoretical Biology (MIT Press, 2011).

That book concentrated on the convergent evolution of life on land, and on those forms of terrestrial life that have secondarily returned to the oceans. The convergent evolution of marine life was largely neglected, and I now wish to begin a new project that I have tentatively entitled Convergent Evolution in the Oceans: Limited Marine Forms Most Beautiful.

What I find most fascinating in this new research project are the numerous examples of the convergent evolution of marine organic forms that are strikingly similar to those of terrestrial animals and plants. But marine organisms evolved these forms first – that is, terrestrial plants and animals have convergently evolved forms that are similar to those previously evolved by organisms living in the oceans.

The sea "lily" is a particularly striking example of the convergent evolution of form in marine animals (first) and its re-evolution of land plants (second): a marine sea lily crinoid echinoderm looks remarkably like a terrestrial palm tree. Both possess branched root systems, a long stem trunk, and a crown of branches at the top of the trunk. Yet these two tree-forms have evolved in radically different environments: oceanic waters versus terrestrial dry land, and one is an animal and the other is a plant!

Why have such similar forms been convergently evolved by such vastly different forms of life (animal vs plant) and in such vastly different environments (oceans vs dry land)? That is the question I wish to think about at the KLI in this new research project.

**Mike STEEL**

(June 2016)



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*Mike Steel is Professor of Mathematics and Director of the Biomathematics Research Centre at the University of Canterbury, Christchurch, New Zealand. His research interests include combinatorics, stochastic processes, and applications in evolutionary biology and related areas. He is an elected fellow of the Royal Society of New Zealand and has around 240 research publications, including two books on mathematical phylogenetics (2003, 2016).*

**Autocatalytic Sets and the Origin of Life**

In an ongoing collaboration with Dr. Wim Hordijk (KLI Senior Fellow) we have studied autocatalytic sets in the context of the origin of life. Autocatalytic sets are self-sustaining chemical reaction networks in which all reactions are catalyzed by at least one of the molecules in the network, and where these molecules can be built up from a basic food source by using only reactions from the network itself.

In previous work we have investigated the properties of autocatalytic sets in detail using a simple polymer model of chemical reaction systems. For example, we showed that autocatalytic sets are highly likely to exist in random instances of this model, also for chemically very realistic levels of catalysis, and that they tend to have a hierarchical structure consisting of smaller and smaller autocatalytic subsets. Thus, autocatalytic sets appear to possess the necessary properties for their spontaneous emergence and further evolution from prebiotic chemistry.

We have also applied our formal autocatalytic sets framework to real chemical and biological reaction networks, such as a system of mutually catalytic RNA molecules, and the metabolic network of *E. coli*. This has led to additional insights into these systems that would be difficult to obtain from chemical experiments alone.



We are currently looking into more details of the required levels of catalysis for autocatalytic sets to exist under various model assumptions, and how we can also deal with inhibition (next to catalysis).



### **Ulrich STEGMANN**

(July 2016 – August 2016)

*Ulrich Stegmann holds PhDs in Zoology and Philosophy. He is a Visiting Professor for Philosophy of the Life Science at the Universiteit Utrecht and a Senior Lecturer in Philosophy at the University of Aberdeen. Previously, he was a British Academy Postdoctoral Fellow at the King's College London, a Teaching Associate at the University of Bristol, and a British Academy Postdoctoral Fellow at the University of Cambridge.*

### **Genetic Information: Philosophical Lessons from the History of Actual Usage**

Semantic concepts such as information, meaning, and representation are used in many areas of the life sciences, and they are used in contexts that seem otherwise describable in purely causal and structural terms. This raises the question of whether semantic notions are merely metaphoric ways of speaking or whether they are 'substantive' theoretical concepts, e.g. concepts that play a significant explanatory role in a scientific field. Although this question has been explored by philosophers for nearly 20 years, views still diverge. The controversial status of semantic concepts in the life sciences has generated a sizable literature in philosophy of biology. The concepts that have received the most attention are genetic coding and genetic information. However, most of the studies pay little attention to how semantic concepts are actually employed. What is missing is a detailed analysis of actual usage of 'genetic information' and similar concepts. The overall aim of this project is therefore to understand the

status of semantic concepts in the life sciences by using a new methodological approach, i.e. by investigating actual usage in detail.

An analysis of actual usage is crucial for (1) determining the content of 'genetic information', including its purported referent(s), its inferential role(s), and its associated epistemic aims, and (2) assessing whether and to what extent it played theoretical roles. For instance, was 'genetic information' employed in explanations or for predictions? Identifying such theoretical roles will be important for assessing the legitimacy of apparently semantic concepts. This project will focus specifically on 'genetic information' and is restricted to the years 1953–1958, the time when an initially small group of scientists began using the notion of 'genetic information' in a sustained way. The scientists to be investigated are the protagonists of 'genetic information' at the time. Much of the unpublished material from this period is available online, especially through the Wellcome Library and the Cold Spring Harbor Archives.

### **Janina WELLMANN**

(September 2016)

*Janina Wellmann is Junior Director of the DFG-College Research Group „Medienkulturen der Computersimulation“ (mecs), Leuphana Universität Lüneburg.*



### **Computer Simulation in the Modern Life Sciences**

Over the past few decades computer simulations have attained an ever-growing importance in many scientific disciplines. Recently, scholars have started debating the wider philosophical, cultural, and social aspects of this historical development. Despite the increasing wealth of literature on the subject, surprisingly few case studies exist, which explore the many ways and historical trajectories of computational methods in general and computer simulations in particular.



In my work I explore case studies in different fields of the biological sciences and their use of simulations. In particular, I am interested in the use of simulations to conceptualize and depict organic processes and motion. Recent developments in the biomedical sciences suggest that research into motion has been gaining increasing attention for the last 50 years or so. Cell motility, for example, is of central importance here. Research on cell motility has emerged in various fields, such as microbiology (amoeba), physiology and immunology (leucocytes), embryology (cell migration during morphogenesis), cancer research (metastasis), and wound healing and regeneration (fibroblasts). The project investigates the role and function of simulation in the biological endeavor to understand biological processes. Can we apply our existing battery of analytic tools to the study of simulation-based science? Are simulations merely a technologically sophisticated tool for modeling or rather an alternative (virtual) form of an experimental system? Existing scholarship tends to concentrate on the relation between simulation and 'models', as well as on the validity of computer-based simulations as a source for prediction/prognosis and testing/proof. At the same time, the use of computer simulation in biology is as vast as it is diverse. With the help of case studies the project aims at investigating in detail recent uses of simulations and their relation to tools and devices previously employed in various fields. A research interlude at the KLI would enable me not only to discuss the case studies and the epistemological status of simulations in biology but also to engage with the biologists in residence in order to learn from their practices and experiences.

## 2.6 Scientists with Own Funding

### **Lorenzo BARAVALLE**

(May 2016 – July 2016)



*Lorenzo Baravalle is an Associate Professor of Epistemology at the Federal University of ABC, São Paulo, Brazil. He has been awarded a Fellowship by the Sao Paulo Research Foundation FAPESP to work on his project at the KLI.*

### **Invariance and Unification in Cultural Evolution Theory**

Inspired by Woodward's account of causation and explanation, Caponi has recently defended that biology – and, especially, evolutionary biology – is grounded on a “mosaic of invariants,” that is, a net of causal regularities which, although not stable and universal enough to constitute genuine causal laws, may guarantee the explanatory autonomy of this discipline by supporting a certain number of relevant counterfactuals. In spite of lacking proper causal laws, evolutionary biology is a unitary theory because invariants are, in some sense, “subsumed” by other kinds of laws – the zero force laws, like the Hardy-Weinberg equilibrium, and the consequence laws, like the laws of population genetics – which connect them within a more general theoretical framework. Might the explanatory structure of a hypothetical unified theory of cultural evolution be conceived in a similar way? The goal of the present project is to provide an answer to this question, by considering two related problems. Firstly, I shall attempt to identify the zero force laws and the consequence laws of the theory of cultural evolution. Secondly, I shall assess two case studies (namely, the rise and fall of empires and the evolution of technology), in order to determine if the causal regularities that are invoked in cultural evolutionary explanations may count as genuine invariants, in Woodward's and Caponi's sense.



**Lynn Chien-Hui CHIU**

(May 2016)

*Lynn Chien-Hui Chiu has a PhD in Philosophy from the University of Missouri. Her dissertation project concerned the impact of organismal activities and cognitive abilities on natural selection explanations. She has a MA in Philosophy from the University of Missouri and a MS in Psychology from National Taiwan University, with a BS in Life Sciences from National Yang Ming University. She is a Postdoc at the University of Bordeaux/CNRS.*

### **Holobiont and Eco-Immunity**

Advances in microbiome research allow us to question the nature of “us”, the microbiota & host, as biological individuals (“holobionts”). One aspect of the holobiont is the symbiotic construction of host & host-microbial immunity. Findings in this area show that the immune system must be considered in its internalized and external ecological context, not just to assess its evolutionary context and trade-offs, but to fully understand the immune system’s symbiotic development and activities.

My research under Thomas Pradeu’s ERC grant examines how host-microbiota eco-immunity challenges an internalist paradigm in immunology that comes from two sources: genetic determinism and the self/nonself model of immunity. We argue that holobiont immunity is co-constructed by host and microbiota and transmitted to the next generation.

At the University of Bordeaux, I am embedded within the Immuno ConcEpT Lab (Immunology, from Concepts and Experiments to Translation). The empirical aspect of my work is conducted in collaboration with two scientific groups, a microbiota group (which includes members of the rheumatology unit of the teaching hospital of the University of Bordeaux) and an innate lymphocyte cell group focused on the diverse roles of immunity.

**Valerie RACINE**

(June 2016 – December 2016)



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*Valérie Racine has a Bachelor's degree in Philosophy from McGill University, a second Bachelor's degree in Journalism and a Master's degree in Philosophy from Concordia University. She transferred to ASU's Center for Biology and Society after beginning her PhD in Philosophy at the University of Western Ontario. With a background in philosophy of science, Valérie went to ASU to learn more about research methods in molecular genetics and genomics and to develop her dissertation project on the interaction between different investigative strategies in research on genetic regulation. She recently completed her PhD in History and Philosophy of Science at ASU and will begin a position as Assistant Professor of Philosophy at Western New England University in 2017.*

**Beyond Reductionism and Emergence: A Study of the Epistemic Practices in Gene Expression Research**

A central task for historians and philosophers of science is to characterize and analyze the epistemic practices in a given science. The epistemic practices of a science include setting its goals or aims, and using certain methods to achieve these goals. My dissertation project addressed the epistemic practices in gene expression research spanning the mid-twentieth century to the twenty-first century. I assess some of the standard historical narratives of the molecular life sciences to clarify certain philosophical problems with respect to reduction, emergence, and representation, and offer new ways with which to think about the development of scientific research and the nature of scientific change.

**Klaus STIEFEL**

(September 2016 – October 2016)

*Klaus M. Stiefel was born and raised in Austria, and received his undergraduate degree from the University of Vienna in 1998. In 2002 he received his Doctorate in Zoology from the University of Vienna and the Max Planck Institute for Brain Research in Frankfurt, Germany. Research stints at the Salk Institute, OIST, Okinawa and the University of Western Sydney followed. Klaus is currently based in the Philippines as an independent scientist, photographer, author, and scuba instructor, and is also affiliated with the Neurolinx Institute based in La Jolla, CA. He pursues commercial science projects with MyScienceAgents, also based in La Jolla.*

**Evolution of Marine Fishes**

Klaus Stiefel is interested in the evolution of marine fishes, especially of their reproductive behavior and symbiosis. In a current project, he investigates the shrimp–goby symbiosis occurring in shallow, sandy areas in tropical and subtropical marine ecosystems. In this symbiosis, a gobiid fish uses a burrow dug by an alpheid shrimp in exchange for lookout duties by the large-eyed fish. Using data from the Fishbase database, we compare the the relative eye size of gobies in a shrimp–symbiosis, and solitary gobies. We find no larger relative eye size, and hence no additional investment of the symbiotic gobies into their visual systems as a consequence of the symbiosis.

## 2.7 Artists in Residence

### Gemma ANDERSON

(September 2016)



*Gemma Anderson is an artist, researcher and university lecturer whose practice is at the interface of art, science and philosophy. With an original focus on drawing as epistemology for morphology and as an alternative approach to classification, she has successfully collaborated on a number of innovative art/science projects. These include 'Hidden Geometries' (Leverhulme Trust Artist in Residence Award 2012) in collaboration with the Mathematics Department at Imperial College London; 'Isomorphology' and the 'Cornwall Morphology and Drawing Centre' (Falmouth University Research and Innovation Award, 2014 & 2015) in collaboration with the Darwin Centre at the Natural History Museum, London; and 'Portraits: Patients and Psychiatrists' (Wellcome Trust Arts Award 2009) in collaboration with psychiatrists and patients at Bethlem Royal Hospital. After studying Fine Art Printmaking at the Royal College of Art and Falmouth University and working on different collaborative projects with mathematicians and natural scientists, she went on to complete a practice based PhD at the University of the Arts London (2015). She was artist in residence for the Northern Ireland Science Festival (2016) and is currently artist in residence at Imperial College (Mathematics department). She has received several prizes and grants such as the Leverhulme Artist in Residence Award, the Wellcome Trust Arts Award, the Thomas Dammann Memorial Trust Award, and the Arts Council Individual Artist Award. Her work has been exhibited widely, as for example at the Victoria and Albert Museum, Freud Museum and the Wellcome Collection, London and in her recent solo exhibition 'Isomorphology' in London and Berlin. She is Associate Lecturer of Drawing at Falmouth University, Cornwall, research fellow at Egenis (Centre for the*



*study of life Sciences), University of Exeter and Drawing Research Associate for The Big Draw UK. She has been a keynote speaker at the International Thinking Through Drawing Symposium, London. Recent publications include 'On Drawing and Mathematics: From Inverse Vision to the Liberation of Form' and 'Endangered: A study of the Declining Practice of Morphological Drawing in Zoological Taxonomy', Leonardo Journal, MIT Press and 'Drawing Resemblance and Isomorphology', Architectural Theory Review, Taylor and Francis. Alongside academic publications, Anderson has produced a limited edition Artist's Book series including 'Portraits: Patients and Psychiatrists' Wellcome Trust, London, and 'Isomorphology' with Super-Collider, London and Atlantic Press, Cornwall. Anderson's forthcoming book *Drawing as a Way of Knowing in Art and Science* will be released with Intellect Press (University of Chicago Press) in September 2017*

### **Representing Biology as Process**

This pilot project aims to explore the epistemological value of drawing for contemporary scientific practice at the KLI. Through practice-based study, Anderson will develop new drawing methods that demonstrate the potential for exploring biological/morphogenetic process through the combination of artistic and scientific methods. Unlike more standard 'visual explanations', drawing harnesses human creativity as an integral part of the interpretation and representation of phenomena.

This project will explore the potential of drawing as a way of representing and interrogating biological processes, especially in relation to morphological evolution (Celeste Pérez Ben, Barbara Fischer and Gerd Müller) and the analysis of dynamical systems in terms of phase space geometry (Berta Verd and Johannes Jaeger). This project is timely as these fields are fast developing whereas the epistemological value of the image – as process and object – within these sciences remains largely unexamined.

Anderson is an artist, researcher and university lecturer whose practice is at the interface of art, science and philo-

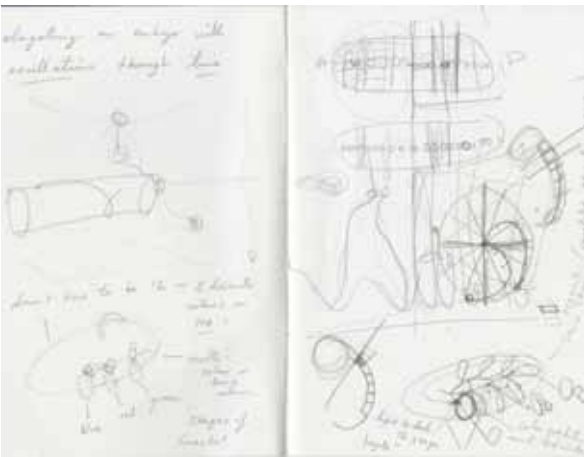
sophy. With an original focus on drawing as epistemology for morphology and as an alternative approach to classification, she has successfully collaborated on a number of innovative art/science projects. These include 'Hidden Geometries' (Leverhulme Trust Artist in residence Award 2012) in collaboration with the Mathematics Department at Imperial College London; the 'Cornwall Morphology and Drawing Centre' (funded by Falmouth University Research and Innovation Award, 2014 and 2015) in collaboration with the Darwin Centre at the Natural History Museum, London; and 'Portraits: Patients and Psychiatrists' (Wellcome Trust Arts Award 2009) in collaboration with psychiatrists and patients at Bethlem Royal Hospital. Anderson's PhD research (co-supervised by John Dupré) included the 'Isomorphology' project (in collaboration with the Natural History Museum), in which she used drawing to create an alternative and visual approach to the classification of animal, mineral and vegetable species. Following Isomorphology, under the influence of Dupré's Process Philosophy of Biology, Anderson began to realise a processual view of biological form through the drawing method and process-oriented series of drawings 'Isomorphogenesis' (2014). She has participated in both Process Biology Workshops at Egenis, first through an exhibition of 'Isomorphogenesis' and second through the delivery of a short drawing workshop.

In her work, Anderson has explored the epistemic potential of drawing in the context of biology and mathematics and its role in articulating a 'representational grammar' (Kress and Leewen, 2006) to facilitate the understanding of complex scientific concepts that can be difficult to achieve through description alone (Anderson, 2014; Anderson et al., 2015). The processual nature of biological phenomena raises new problems, in that a visual image must attempt to represent four dimensions (three spatial dimensions, and time). Whereas technologies for presenting moving images, such as timelapse videos, offer advantages over static technologies, they nevertheless create distance between the interaction with the phenomena represented and the representation. Drawing provides a more engaged access to and reflection on the phenomenon of investigation than merely 'witnessing' the mechanical generation of biological representations through

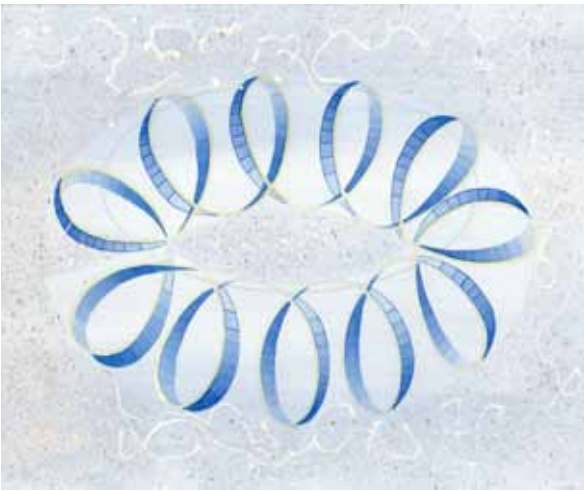


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various imaging devices. In this project, Anderson aims to position drawing as an interdisciplinary tool and practice for the visual understanding of types of biological processes and their dynamic interactions. Here she will build on experience of drawing morphological development in four dimensions in collaboration with mathematician Alessio Corti (Anderson and Corti, 2015), and further develop this work by integrating methods by artists such as Paul Klee who have pioneered techniques for the representation of dynamics.

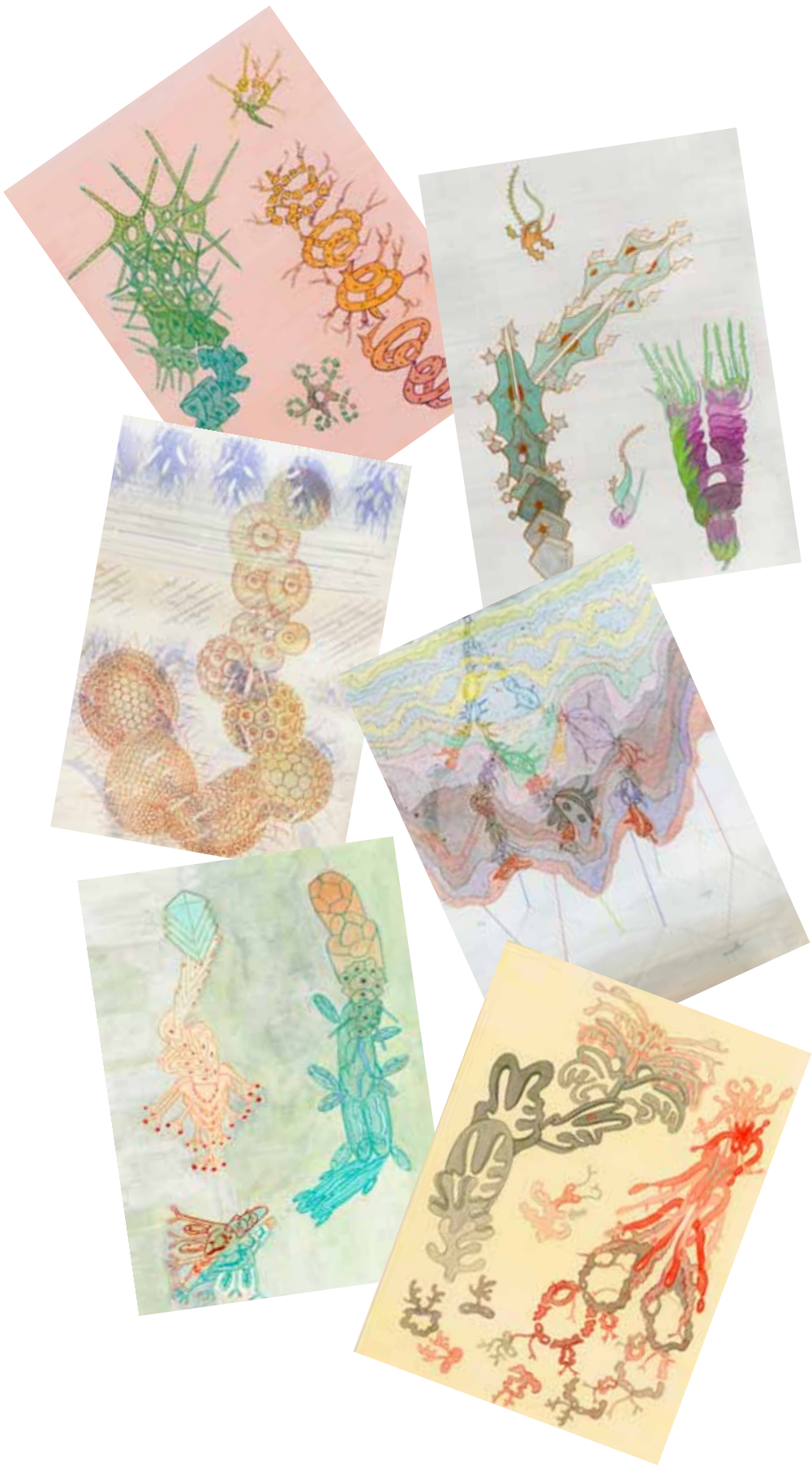


Somitogenesis/Oscillations. Collaborative drawing with B. Verd (KLI)



Somitogenesis/Oscillations. Watercolor and pencil on paper







## **Felix SCHOLZ**

(May 2016 – June 2016 & September 2016)

*Felix Scholz studied architecture at the Bauhaus-Universität Weimar, Università Federico II Napoli, and Universität der Künste, Berlin. He holds an architectural diploma from the Bauhaus-Universität Weimar. He works as a freelance artist in Leipzig and Berlin.*

### **An Artistic Diary: Illustrations of the KLI**

Felix Scholz' work aims to document his stay in form of a graphic diary. He portrayed the people he met and talked to at the institute as well as captured the spirit of the institute by fast sketches at and around the site.

The online diary can be found at:

<http://www.felixscholz.net/portfolio/artist-in-residence-konrad-lorenz-institute-klosterneuburg-austria/>





## Meetings and Lectures

# 3

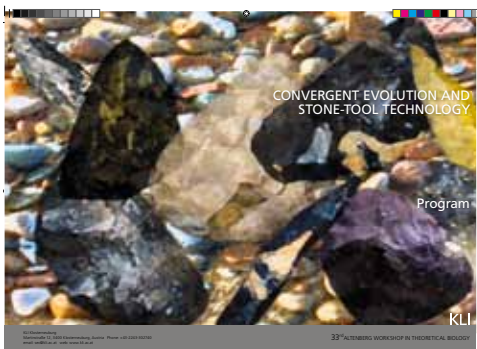


*The KLI supports international workshops, symposia, and individual talks that are organized by the KLI or in cooperation with other institutions.*

### 3.1 Altenberg Workshop in Theoretical Biology

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*The “Altenberg Workshops” address key questions of biological theories. Each workshop is organized by leading experts of a certain field who invite a group of international specialists to the KLI. The Altenberg Workshops aim to make conceptual progress and to generate initiatives of a distinctly interdisciplinary nature. Further information concerning the participants and their presentations can be found on the KLI website. Workshops hosted at the new institute building in Klosterneuburg are continued as “Altenberg Workshops.”*



**33<sup>rd</sup> Altenberg Workshop  
in Theoretical Biology  
16 – 19 June 2016**

**Convergent Evolution and  
Stone-Tool Technology**  
*KLI Klosterneuburg*

*Organization: Briggs Buchanan, Metin I. Eren, Michael J. O’Brien*

#### Topic and Aims

Stone tools and the debris from stone-tool manufacture are found throughout the archaeological record of humans and their ancestors. The first unambiguous hominin-produced tools appeared approximately 2.6 million years ago (de la Torre 2011), although recent studies have shown indirect evidence that hominins began using stone tools nearly 3.4 million years ago (McPherron et al. 2010). Stone has been used to make tools in nearly all of the regions of the globe that have been inhabited. Given the nearly ubiquitous use of stone tools by hominins, their study is an important line of inquiry for shedding light on questions of evolution and behavior. Researchers have been studying stone artifacts for over a century and have investigated a wide range of topics, including the evolution of technology, prehistoric economy, hominin global dispersals, and the ancient engineering of tools, but the topic of evolutionary convergence remains an understudied yet potentially important avenue of research.

Convergence is the phenomenon in which evolutionary processes result in the same, or similar, forms in independent lineages as a result of functional or developmental constraints (McGhee 2011). In studies of stone tools, identifying cases of convergence is of particular importance because similarities in form and func-



48 tion are often used to suggest historical connections among prehistoric groups. Identifying cases of convergence would refute hypotheses that otherwise would suggest some degree of physical or cultural connection among toolmakers. The reason that convergence remains understudied has to do in large part with the unsupported assumption that there are “endless” stone-tool production techniques and forms, and thus “independent innovation in stone tools is incredibly rare” (Bradley, as quoted by Cook 2012).

Considerable reason exists to doubt this widely held belief because the manufacture of stone tools is a reductive process, whereby stone flakes are removed from larger cores to make smaller tool forms. As stone is reduced, the number of possible outcomes in terms of form becomes increasingly constrained. Widespread convergence of lithic technologies is also possible as a result of the fracturing properties of stone, which are governed by a specific set of physical constraints (Dibble and Pelcin 1995; Magnani et al. 2014).

The vast array of stone types that are appropriate for stone-tool manufacture—flint, obsidian, basalt, and quartzite, for example—contain the same basic set of fracture properties, which increases the possibility of convergence (e.g., Braun et al. 2009; Eren et al. 2011, 2014). Moreover, prehistoric people, albeit in different times and places, would have faced similar adaptive challenges that would have ostensibly governed stone-tool forms toward similar optimal designs (“adaptive peaks”) (Lycett and Eren 2013). Considering all these factors, it should be no surprise that several recent studies are empirically consistent with the hypothesis that convergence in lithic technology is not rare (Eren et al. 2013, 2014; Lycett 2009, 2011).

## Program

R. ALEX BENTLEY  
University of Houston

### **Convergent Evolution and Technological Change**

BRIGGS BUCHANAN  
University of Tulsa

### **On the Probability of Convergence among North American Projectile Points**

MATHIEU CHARBONNEAU  
Centra European University, Budapest

### **Technical Constraints on Artifact Evolution: From Morphological Models to Theoretical Technospaces**

JUDITH CHARLIN

Universidad de Buenos Aires

**Reduction Constraints and Shape Convergence along Tool Ontogenetic Trajectories: An Example from Late Holocene Projectile Points of Southern Patagonia**

CHRISTOPHER CLARKSON

University of Queensland, Brisbane

**Small, Strong, Sharp, and Easy to Make the Same Way Each Time: Experimental and Archaeological Investigations into Convergence in Microlithic Technology**

LOREN DAVIS

Oregon State University, Corvallis

**The “Levallois-like” Technological System of the Western Stemmed Tradition: A Case of Convergent Evolution in Early North American Prehistory?**

HAROLD DIBBLE

University of Pennsylvania, Philadelphia

**How Do We Recognize Convergence in Lithics?**

METIN I. EREN

Kent State University

**Why Should Convergence Be a Potential Hypothesis for the Emergence of Stone-tool Form and Production Processes? An Illustration Using Stone Tool Replication**

MARCUS HAMILTON

Santa Fe Institute

**The Biogeography of Human Cultural Diversity**

TOM JENNINGS

University of West Georgia, Carrollton

**Clovis and Toyah: Convergent Blade Technologies in the Southern Plains Periphery of North America**

STEVEN L. KUHN

University of Arizona, Tucson

**Detecting Homologies without Reliable Phylogenetic Information Is the Challenge for Lithic Studies**

DANIEL E. LIEBERMAN

Harvard University, Cambridge

**How Did Early Humans Hunt?**





GEORGE MCGHEE

Rutgers University, New Brunswick

**Limits on the Possible Forms of Stone Tools: A Perspective from Convergent Biological Evolution**

MICHAEL J. O'BRIEN

University of Missouri, Columbia

**Archaeological Perspectives on Convergence**

ASHLEY SMALLWOOD

University of West Georgia, Carrollton

**The Convergent Evolution of Serrated Points in the Eastern Woodlands, North America**

JAYNE WILKINS

University of Cape Town, Rondebosch

**The Point Is the Point: Emulative Social Learning and Weapon Manufacture in the Middle Stone Age of South Africa**

## 3.2 Science Forum

*The Science Forum uses an unusual, flexible, multi-disciplinary approach, implemented by facilitators. The Science Forum is interactive, dynamically adjusted to the needs of participants, involving individual, pair and group work, as well as group discussions and feedback rounds. This allows identifying common research interests and potential issues concerning methodology, concepts, or communication between participants.*



### 1<sup>st</sup> Science Forum 17 – 20 November 2016

**Two Sides of the Same Coin:  
Mechanistic and Population-Level  
Perspectives on Evolution**  
KLI Klosterneuburg

Organization: Joanna Masel & Johannes Jaeger

### Topic and Aims

Evolution not only involves population-level processes such as natural selection. We can no longer maintain Mayr's famous distinction between ultimate and proximate causes in biology. There is feedback between the two kinds of processes: the non-random phenotypic variation that is subject to selection originates from mechanisms at the level of the individual. These include molecular self-organization, metabolism, physiology, gene regulation, development, and interactions between organisms and their environment. Because these mechanisms are complex and non-linear, we do not yet understand how mutations affect the evolution of phenotypic traits. This challenge is currently being tackled by two complementary approaches. Evolutionary geneticists (using a top-down approach) seek quantitative insights into genetic architecture and gene-environment interactions, while molecular, cell and developmental biologists (using a bottom-up approach) seek causal, mechanistic understanding of biological systems. On the one hand, these approaches overlap in addressing concepts such as variational properties, constraints, epistasis, robustness, and evolvability. On the other hand, they remain largely disconnected in practice, because of significant methodological and conceptual differences. This leads to misunderstandings and controversies hindering



52 progress in the field of evolutionary theory. To overcome this roadblock, a new and focused approach at interdisciplinary communication is necessary. We propose a workshop with an unusual, flexible structure, which dynamically adjusts to the needs and interests of the participants. The goal is to enable a constructive dialogue between researchers in different communities. This allows us to identify both synergies and areas of creative tension between fields. One important outcome will be to enable and foster sustained collaborations between participants. Another will consist of a general positional paper on methodological and conceptual issues, which will profit from interactions between the two approaches. Additionally, the workshop will generate more specific conceptual publications on problems that arise during our discussions.

Understanding the evolution of phenotypes from both an evolutionary genetics and mechanistic perspective could result in the discovery of regularities, or even fundamental rules, underlying general trends in evolution. What kind of organisms can or cannot evolve? Tackling such important questions is essential if we are to ultimately understand our own origins. Therefore, the unification of these two perspectives is of the highest priority. In addition, both evolutionary genetics and mechanistic approaches to biology are changing rapidly at the moment, due to the increasing application of systems-biology and 'omics' approaches. This raises methodological and conceptual challenges. It also provides a timely opportunity to reassess traditional disciplines, their boundaries, overlaps, and potential incompatibilities, to give rise to original, multidisciplinary research into novel questions. Finally, understanding mutational effects on phenotypes is not only crucial to gain insight into evolutionary dynamics, but is also essential for diagnosis and treatment of the genetic predispositions and causes of human disease. It is an absolute prerequisite if we are ever to achieve the aim of an individualized medicine. In this sense, basic research into the evolution of mechanistic processes provides powerful models to develop the methodological and conceptual foundation for addressing these more applied questions.

## Participants

NICK BARTON

Institute for Science and Technology Austria, Klosterneuburg

IAN DWORKIN

McMaster University, Hamilton

CASSANDRA EXTAVOUR

Harvard University, Cambridge

JOHANNES JAEGER  
KLI, Klosterneubrg

JUKKA JERNVALL  
University of Helsinki

REES KASSEN  
University of Ottawa

ABDERRAHMAN KHILA  
École Normale Supérieure Lyon

JOANNA MASEL  
University of Arizona, Tucson

PHILIPP MITTEROECKER  
University of Vienna

STIG W. OMHOLT  
Norwegian University of Science & Technology, Trondheim

ANNALISE PAABY  
Georgia Institute of Technology, Atlanta

MIHAELA PAVLICEV  
Cincinnati Children's Hospital, University of Cincinnati

SAHOTRA SARKAR  
University of Texas, Austin

MARK SIEGAL  
New York University

ARLIN STOLZFUS  
University of Maryland, Rockville

### **Facilitators**

MAGGIE DUGAN & TIM DUNNE  
knowinnovation.com

HILDE JANSSENS  
servusscience.org

54 **3.3 Summer School**

*The European Advanced School for the Philosophy of the Life Sciences (EASPLS) is organized by six top-level European institutions in the philosophy and history of the life sciences. EASPLS aims at fostering research, advancement of students, and collaborations in the field of the philosophy of the biological and biomedical sciences. Meetings are held every other year.*



### **4<sup>th</sup> European Advanced Seminar in the Philosophy of the Life Sciences 5 – 9 September 2016**

#### **Function and Malfunction in the Biological and Biomedical Sciences, and Social Sciences**

*KLI Klosterneuburg*

*Directors: Jean Gayon, Alvaro Moreno & Local Organizer: Isabella Sarto-Jackson  
Organizers: University of Exeter; University of the Basque Country; IHPST Paris-1 Sorbonne; Leibniz University Hannover; University of Geneva; KLI*

#### **Topic and Aims**

Functional ascriptions and functional explanation have been major topics in philosophy of science since the 1950s. A turning point was attained in 1973, when Larry Wright proposed his 'etiological theory of function', according to which 'The function of X is Z means (a) X is there because it does Z ; (b) Z is a consequence (or result) of X's being there.' According to Wright, such a definition of function satisfied three requirements that were essential to him: (1) it offered a criterion for distinguishing a function from a mere effect; (2) it applied both to biology and to artifacts; (3) it was able to capture the normativity of functional ascriptions, that is the implicit assumptions that malfunction is always a possibility (a given object may have a function, and nevertheless be unable to accomplish that function).

Shortly after Wright's article, in 1975, Robert Cummins proposed a very different definition of function, according to which ascribing a function to something 'is to ascribe a capacity to it which is singled out by its role in an analysis of some

capacity of a containing system'. Contrary to the 'etiological' theory, which looks backwards, the 'causal role' theory of function looks forward. As Wright's concept of function, Cummins' concept applied both to biological and technical objects, but did not take into account normativity. In open opposition to Wright, Cummins insisted that functional ascriptions had nothing to do with the past history of a system, and should be understood exclusively from the viewpoint of the present organization of a system. Because Cummins (erroneously) reduced Wright's concept of function to that of 'selected effect', Wright's and Cummins' seminal papers were the origin of an ongoing debate between authors adhering to 'backward looking' or 'evolutionary' theories of function, and authors defending a 'forward looking' or 'dispositional' theories of function.

Another philosopher who played an important role was Christopher Boorse, who proposed in 1976 to define function as the causal contribution of something to a goal in a teleological system. This concept is close to Cummins' concept, but the originality of Boorse was to connect the debate of function with the debate on health and disease. For Boorse, function is a non-normative concept, itself part of a non-normative concept of disease and health: disease is no more than dysfunction; and health is 'typical functioning', defined in terms of available physiological knowledge and statistical normality. Correlatively, for Boorse, in sum, normative issues come into play only for a subclass of human disease, which he calls 'illness'. Illness is disease plus subjective and social components. Yet, since Boorse defines disease in terms of statistical abnormal functioning of a specific trait in comparison with the average functioning of traits of the same type in individuals of a concrete "reference class" (members of the same species, gender and age), and health, instead, as simply the absence of disease, its view raises many difficulties to establish a clear frontier between healthy (normal) and unhealthy (abnormal) levels of functioning without adducing subjective and arbitrary considerations. And in this sense, it is dubious that this approach can be really consistent with a biologically grounded theory of functions.

This debate on the other hand, goes beyond the domain of Life Sciences and affects in many aspects nuclear questions of the social sciences. In particular, the debate about functions and malfunctions has affected directly the philosophy of technology, questioning whether the biological theories of function (and malfunction) could or could not be applied to human made artifacts.

The purpose of the 4th European Advanced Seminar in the Philosophy of the Life Sciences (EASPLS) is to reassess the modern philosophical debate on function



56 in the dual perspective of (1) malfunction (or dysfunction), and (2) with respect to the use of such concepts in both the biological and the social sciences, with a particular concern for the interrelations and interactions between these two fields.

- Should the concept of function leave room for normativity? If yes, how?
- How does this relate to reflections about malfunction?
- To what extent does the debate about health and disease in the philosophy of medicine meet with the function/malfunction debate?
- How can the social sciences contribute/have contributed to this debate?
- Speaking of malfunction seems to imply that there is something like “normal” functioning (Boorse); can this be a objective concept or not?
- What is the reference system for the concept of function/malfunction (e.g., levels of organization below and above the organismal level)?
- To what extent is it appropriate to speak of function or malfunction in the social or economical sciences?
- Do we need a common concept of function and malfunction for the biological, social and technological domains?
- Has the philosophical reflection about malfunction, dysfunction, and abnormality significantly evolved over the past 40 years?

## Program

GERD B. MÜLLER

KLI & University of Vienna

### Welcome Address

ALVARO MORENO

University of the Basque Country, San Sebastian

### What are Biological Malfunctions?

DANIEL NICHOLSON

University of Exeter

### Structure and Function: A Process-Centred View

WESLEY HERB ANDERSON

KLI, Klosterneuburg

### Commentary on: Structure and Function: A Process-Centred View



VICTOR LEFÈVRE

IHPST Paris Sorbonne

**On Defense of the Organizational Account of Ecological Functions**

PARISA MOOSAVI

University of Toronto

**Can the Biological Accounts of Function Be Applied to Human Morality?**

DAVID SUAREZ PASCAL

National Autonomous University of Mexico, Mexico City

**Function and Value: Calibrating Philosophical Theories of Function Through Their Evaluative Compromises**

DANIEL DZAH

Central European University, Budapest

MICHAL HLADKY

University of Geneva

MARK PERLMAN

Western Oregon University, Monmouth

**Round Table: Function, Normativity, and Teleology in Biology and Technology**

Moderated by JOHANNES JAEGER

KLI, Klosterneuburg

THOMAS REYDON

University of Hannover

**Kind-Formation for Functionally Defined Groups**

ÇAGLAR KARACA

University of Exeter

**Commentary on: Kind-Formation for Functionally Defined Groups**

MARCEL WEBER

University of Geneva

**How Objective are Biological Functions?**

ALEKSANDRA KORNIENKO

Medical University of Vienna

**Commentary on: How Objective are Biological Functions?**



58 ZACHARY ARDERN

University of Auckland

**Evolution, Dysfunction, and Disease: A Response to Griffiths and Matthewson**

LENNART NORDENFELT

University of Stockholm

**Functions and Health**

MAXIMILIAN HUBER

University of Geneva

**Commentary on: Functions and Health**

ÉTIENNE ROUX

IHPST Paris Sorbonne

**Normality, Function, Dysfunction in Biology: Function as a Variable**

BRANDON CONLEY

Cornell University, New York

**Putting Dysfunction to Work in Functional Analysis**

MARK CINCIANI

Universidad del Pais Vasco, San Sebastian

**The Organizational Theory of Functions and Multi-Level Functions**

MATTEO MOSSIO

IHPST Paris Sorbonne

**The Organizational Account of Biological Functions**

RIANA BETZLER

University of Cambridge

**Commentary on: The Organizational Account of Biological Functions**

ARANTZA ETXEBERRIA

University of the Basque Country, San Sebastian

**On the Biological Organization of Pathologies: Functions, Relations and the 'Normal–Broken' View**

STEFANO CANALI

University of Hannover

**Commentary on: On the Biological Organization of Pathologies:  
Functions, Relations and the 'Normal–Broken' View**

JAMES DIFRISCO

KLI, Klosterneuburg

**Functional Explanation and Functional Equivalents**

CHRISTOPHER PARKER

University of Cincinnati

**Two Varieties of Dysfunction in Mental Disorder**

PAOLA HERNANDEZ CHAVEZ

Centro Lombardo Toledano, Mexico City

**Cognitive Dysfunctions in Neuroscience: Stuck in Old Biology**

THOMAS BONNIN

University of Exeter

FABIAN HUNDERTMARK

University of Bielefeld

ALESSANDRA PASSARIELLO

Sapienza University, Rome

**Round Table: Philosophical Theories of Biological Function**

Moderated by ARGYRIS ARNELLOS

KLI, Klosterneuburg

SHANE GLACKING

University of Exeter

**Mad Disease and Martian Disease**

JENNIFER ASSELIN

Ohio State University

**Commentary on: Mad Disease and Martian Disease**

ISABELLA SARTO-JACKSON

KLI, Klosterneuburg

**Plasticity of Functions: The Neuroplasticity – Neuropathology Continuum  
of the Nervous System**



60 EVA FERNANDEZ-LABANDERA TEJADO

University of the Basque Country, San Sebastian

**Commentary on: Plasticity of Functions: The Neuroplasticity –  
Neuropathology Continuum of the Nervous System**

ANNA MARIA DIELI

University of Rome Tor Vergata

**Function as a Goal Oriented Behaviour: The Case of Cancer**

ULRICH KROHS

University of Muenster

**Relating Function and Malfunction to Fixed Types**

DAVID PRÉVOST-GAGNON

Laval University, Quebec

**Commentary on: Relating Function and Malfunction to Fixed Types**

LAURENT LOISON

IHPST Paris Sorbonne

**Concluding Remarks**

### 3.4 Cooperative Events

#### **Joint Workshop Wissenschaftskolleg zu Berlin & KLI College for Life Sciences Meets the KLI 6 – 8 March 2016**

*KLI Klosterneuburg*

##### **Program**

- Introduction of the two Fellowship Programs
- Mutual Introduction of Fellows through Interactive Formats
- Identification of Shared Interest Questions,  
Formation of Discussion Groups
- Tour through the KLI & Klosterneuburg
- Group Discussion – Part I
- Group Discussion – Part II

LUDWIG HUBER

University of Veterinary Medicine, Vienna

##### **Wild Minds: An Exploration into Comparative Cognition**

HILDE JANSSENS

Servusscience.org

##### **Workshop on Communication Skills**

Summaries of Group Discussions/General Discussions

**“Why Do We Need Advanced Study Institutes?”**



62 **Joint Workshop Complexity Science Hub Vienna & KLI  
Methods for Evolutionary Systems  
25 April 2017**

*KLI Klosterneuburg*

*Organized by: Stefan Thurner & Johannes Jäger*

**Program**

STEFAN THURNER

Complexity Science Hub Vienna, Medical University of Vienna

**Overview of Work of COSY at MUW**

WIM HORDIJK

KLI

**Autocatalytic Sets: From the Origin of Life to Economy**

BERNAT COROMINAS-MURTRA

Complexity Science Hub Vienna, Medical University of Vienna

**Emergence of Scaling, Targeted Diffusion, and  
Sample Space Reducing Processes**

LEE ALTENBERG

KLI

**The Deep Connection between Mutational Robustness  
and Mutational Relaxation Time**

RUDOLF HANEL

Complexity Science Hub Vienna, Medical University of Vienna

**Complex Regulatory Systems and Entropies**

BERTA VERD

KLI

**A Damped Oscillator Governs Posterior Gap Gene Patterning  
in *Drosophila melanogaster***

PETER KLIMEK

Complexity Science Hub Vienna, Medical University of Vienna

**Creative Destruction in Schumpeterian Economic Evolution:  
Models & Measures**

**Joint Workshop Complexity Science Hub Vienna & KLI  
Approaches to Evolution of Complex Systems  
11 – 12 November 2017**

*KLI Klosterneuburg*

*Organized by: Stefan Thurner, Johannes Jäger, Ulf Diekmann,  
Manfred Laubichler*

**Topic and Aims**

Evolutionary processes pose fundamental challenges to a quantitative predictive understanding. One of the main reasons for this lack of predictability is the fact that the configuration space of evolving complex systems cannot be pre-stated. Dimensionality and boundary conditions change with every innovation. These systems incessantly explore what Kauffman has termed the adjacent possible. The need to rigorously understand evolutionary systems is bigger than ever before. Humanity as a whole is facing numerous complex challenges. Increased understanding of complex evolutionary dynamics will have wide implications for analysis and management of health, eco-systems, financial markets, societal change, and innovation in the economy.

The aim of this interdisciplinary workshop organized by the Complexity Science Hub Vienna, KLI Klosterneuburg, IIASA, and Arizona State University is to discuss progress in how to conceptualize, quantify, model, and manage the dynamics of evolving complex systems.

**Program**

EÖRS SZATHMÁRY

Eötvös Loránd University Budapest

**Language, Biology, and Luc Steels**

ERIK VAN NIMWEGEN

University of Basel

**Noise and the Evolution of Regulatory Systems**

FRANCESCA TRIA

ISI Foundation

**Innovation Through the Expansion into the Adjacent Possible**





64 IMRE KONDOR

Parmenides Foundation & London Mathematical Laboratory

**On Top and Beyond Networks**

ULF DIECKMANN

IIASA

**Tba**

MANFRED LAUBICHLER

Arizona State University & Santa Fe Institute

**Extended Evolution Theory: Context and History in  
Evolutionary Dynamics**

STEFANIE WIDDER

CeMM

**The Human Microbiome - a Complex Ecosystem in Health and Disease**

STEFAN THURNER

Medical University of Vienna, SFI, IIASA, & CSH

**Combinatorial Evolution and Its Statistics**

KARL SIGMUND

University of Vienna & IIASA

**Special Guest Lecture**

JONATHAN BARD

University of Edinburgh & Oxford University

**Mutation, Variation, and the Schizophrenic Gene**

HANS METZ

IIASA

**How Observations Can Be Misinterpreted Due to the Complexity  
of the Generating System**

BERTA VERD

KLI

**Evolving Developmental Processes with Dynamical Systems**

PAULIEN HOGEWEG

University of Utrecht

**Multilevel Evolution: Evolution of Mutational Neighborhood and New Selection Pressures**

PETER STADLER

University of Leipzig

**Limits of Dynamic Programming**

PETER KLIMEK

Medical University of Vienna

**Evolutionary Dynamics from a Variational Principle**

WIM HORDIJK

KLI

**Evolvability of Autocatalytic Sets**

JOHANNES JAEGER

KLI

**Discussion & Conclusions**

### 3.5 KLI Colloquia

*KLI Colloquia are informal, public talks taking place at the KLI Klosterneuburg. Abstracts of the presentations and information about the lecturers can be found on the website of the institute.*

ERICH BORNBERG-BAUER

Westfalian Wilhelms University Muenster

**Evolution in Sequence Space: How Molecules Navigate a Sheer Endless Space Through a Rugged Fitness Landscape**

RIANA BETZLER

University of Cambridge

**Why We Disagree about Empathy (and What to Do about It)**



LUC STEELS

Institute for Evolutionary Biology, UPF-CSIC, Barcelona

**Progress in Studying Language Origins**

MAX RINGLER

University of Vienna

**Poison Frogs as a Model System for Studying the Evolution of Social Behavior**

MATHIEU CHARBONNEAU

Central European University, Budapest

**Recombination, Modularity, and Hierarchy: The Generative Structure of Cultural Processes**

JOHANNES JAEGER

KLI

**The Evolution of Dynamical Regulatory Systems**

BARBARA FISCHER

KLI

**Why Is Childbirth so Hard in Humans? The Evolvability and Integration of the Human Pelvis**

HAROLD DE VLADAR

Parmenides Foundation, Pullach

**Evolutionary Genetics of Symbiosis with Open-Ended Dynamics**

YOAV SOEN

Weizmann Institute of Science, Rehovot

**Adaptation by Natural Improvisation**

IVAN GONZALEZ CABRERA

KLI & Max Planck Institute, Leipzig

**Sharing our Normative Worlds: The Role of Ontogeny in the Evolution of Normative Thinking**

CHIARA ELETTRA FERRARIO

KLI & Victoria University of Wellington

**Can We Hear from Stones and Sticks? Forays into the Deep Past Through Material Culture in Hominin and Animals**

WIM HORDIJK

KLI

**Dynamics, Emergent Computation, and Evolution in Cellular Automata**

CHRISTOPH FLAMM

University of Vienna

**From Graph Grammars to Evolving Reaction Networks**

BERTA VERD

KLI

**Evolution of Different Dynamic Modes of Segmentation**

ZSOKA VÁSÁRHELYI

KLI & Eötvös Loránd University, Budapest

**The Human Personality Diversification: Evolutionary Models and Hypotheses**

KEPA RUIZ-MIRAZO

University of the Basque Country, San Sebastian

**Nothing in Biology Makes Sense without a Theory of the Origins and Development of Cellular Organization**

FRED KEIJZER

University of Groningen

**Why We May Want a Science of Cognition That Is Not a Science of Mind**

STUART KAUFFMAN

The University of Pennsylvania, Philadelphia

**Beyond Pythagoras: No Laws Entail Evolution**

MARK BICKHARD

Lehigh University, Bethlehem

**Cognition and the Brain**

DANIEL S. BROOKS

KLI

**A New Look at Levels of Organization**

GEORGE MCGHEE

KLI & Rutgers University, Piscataway

**Limits and Directionality in Evolution: A Theoretical Perspective**

JAMES DiFRISCO

KLI

**Kinds of Biological Individuals: Selection and Projectability**



68 ANDRÉ STRAUSS  
KLI & Max Planck Institute, Leipzig  
**Emerging Homo and the Diagnosis of *Australopithecus sediba*: Evaluating the Impact of Cranial Ontogeny in Hominin Alpha Taxonomy**

MIKE STEEL  
KLI & University of Canterbury, Christchurch  
**Darwin's Regret: What Maths Tells Us about the Evolution of Life**

EDIT TALPSEPP  
University of Tartu  
**Some Issues Related to Essentialist Thinking Concerning Biological Species and Human Groups**

STEFANIE WIDDER  
University of Vienna  
**From Gene Regulation to Microbial Communities: Predicting Complex Community Function**

LORENZO BARAVALLE  
KLI & Federal University of ABC, São Paulo  
**Invariance and Unification in Cultural Evolution Theory**

ALBA AMILBURU  
University of the Basque Country, San Sebastian  
**Natural Kinds, Scientific Classificatory Practices, and the Definition of Life**

ULRICH STEGMANN  
KLI & University of Aberdeen  
**Information, Coding, and Genetic Mechanisms**

KLAUS STIEFEL  
Neurolinx Research Institute, La Jolla  
**Fish Reproduction and Symbiosis**

KATRIN SCHAEFER  
University of Vienna  
**Psychomorphospace: An Instrument to Explain First Impressions by Biological Causes of Facial Shape Variation**

JANINA WELLMANN  
Leuphana Universität Lüneburg  
**"But Cells are Matter That Dances": Depicting Cell Trajectories in Embryogenesis**

WESLEY HERB ANDERSON

KLI

**Upshots of Thinking Causally About Selection and a Case of Group Selection among Healthy and Cancer Cells**

CELESTE PEREZ BEN

KLI & University of Buenos Aires

**Miniaturization, Ontogeny, and Phylogeny**

WIM HORDIJK

KLI

**Biologically Inspired Computing**

SARA MURILLO SÁNCHEZ

KLI & University of the Basque Country, San Sebastian

**The Great Opportunity of Biologizing Chemistry:  
A Search for Minimal Functionally Integrated Individuals**

ALFONSO MARTINEZ-ARIAS

University of Cambridge

**Chance, Necessity, and Teleology in the Evo-Engineering of the Vertebrate Body Plan**

LYNN CHIEN-HUI CHIU

CNRS, University of Bordeaux

**Microorganisms as Scaffolds of Host Individuality**

VALERIE RACINE

KLI

**Beyond Reductionism and Emergence: A Study of the Epistemic Practices in Gene Expression Research**

BERTA VERD

KLI

**A Dynamical Systems Approach to EvoDevo**

Publications



*Scientific publications  
and presentations of fellows  
and staff members of the  
KLI in 2016.*



## 4.1 Vienna Series in Theoretical Biology

The 'Vienna Series' is published by The MIT Press as a book series. Books are mainly based on the Altenberg Workshops and the resulting contributions and new syntheses. The book projects are subjected to a reviewing process by The MIT Press.



Volume 18:

NIKLAS KJ, NEWMAN SA, eds

**Multicellularity  
Origins and Evolution**

## 4.2 Professional Papers and Books

ALTENBERG L.

**Norm Statement Considered Harmful: Comment on 'Evolution of Unconditional Dispersal in Periodic Environments '**

Journal of Biological Dynamics 10: 342–346

ALTENBERG L.

**Evolutionary Computation**

Encyclopedia of Evolutionary Biology 2: 40–47

ARNELLOS A, MORENO A.

**Integrating Constitution and Interaction in the Transition from Unicellular to Multicellular Organisms**

In: Multicellularity: Origins and Evolution (Niklas K, Newman S, eds)  
Cambridge, MA: MIT Press, pp 249-275



72 ARNELLOS A.

**Biological Autonomy: Can a Universal and Gradable Conception Be Operationalized?**

Essay Review on Bernd Rosslenbroich's "On the Origin of Autonomy: A New Look at the Major Transitions in Evolution"

Biological Theory 11: 11–24

BARWICH AS.

**What Is so Special about Smell? Olfaction as a Model System in Neurobiology**

Postgraduate Medical Journal/BMJ Journals 92: 27–33

CROMBACH A, WOTTON KR, JIMÉNEZ-GURI E, JAEGER J.

**Gap Gene Regulatory Dynamics Evolve along a Genotype Network**

Molecular Biology and Evolution 33: 1293–1307

FISCHER B, MITTEROECKER P.

**Reply to Underdown and Oppenheimer: Roles of Selection, Plasticity, and Genetics in the Integration of Human Pelvis Shape and Head Size**

Proceedings of the National Academy of Sciences 113: E259

HOERMANN A, CICIN-SAIN D, JAEGER J.

**A Quantitative Validated Model Reveals Two Phases of Transcriptional Regulation for the Gap Gene Giant in Drosophila**

Developmental Biology 411: 325–338

HORDIJK W, STEEL M.

**Autocatalytic Sets in Polymer Networks with Variable Catalysis Distributions**

Journal of Mathematical Chemistry 54: 1997–2021

HORDIJK W.

**Evolution: Limited & Predictable or Unbounded & Lawless?**

Biological Theory 11: 187–191

JAEGER J.

**The Importance of Being Dynamic: Systems Biology beyond the Hairball**

In: Philosophy of Systems Biology: Perspectives from Philosophers and Scientists (Green S, ed), pp. 135–146

Dordrecht: Springer

MITTEROECKER P, FISCHER B.

**Adult Pelvic Shape Change Is an Evolutionary Side-Effect**

Proceedings of the National Academy of Sciences 113: E3596

MITTEROECKER P, HUTTEGGER S, FISCHER B, PAVLICEV M.

**Cliff-Edge Model of Obstetric Selection in Humans**

Proceedings of the National Academy of Sciences 113: 14680–14685

MORIN O.

**The Disunity of “Cultural Group Selection”**

A comment on Richerson et al.’s “Cultural Group Selection Plays an Essential Role in Explaining Human Cooperation”

Behavioral and Brain Sciences 39, e46. 1 2016

NÖDL MT, KERBL A, WALZL M, MÜLLER GB, DE COUET HG.

**The Cephalopod Arm Crown: Appendage Formation and Differentiation in the Hawaiian Bobtail Squid *Euprymna scolopes***

Frontiers in Zoology, DOI 10.1186/s12983-016-0175-8

PETERSON T, MÜLLER GB.

**Phenotypic Novelty in EvoDevo: The Distinction between Continuous and Discontinuous Variation and Its Importance in Evolutionary Theory**

Evolutionary Biology 43: 314–335

SARTO-JACKSON I, MACLEOD M, HANDSCHUH S, FRISCHER C, LANG J, SCHLUMPP M, CALLEBAUT W.

**A Piecewise Aggregation of (Some) Philosophers’ and Biologists’ Perspectives**

Review Essay on William C. Wimsatt: Re-Engineering Philosophy for Limited Beings: Piecewise Approximations to Reality

Biological Theory 11: 1–10

SARTO-JACKSON I, TOMASKA L.

**How to Bake a Brain: Yeast as a Model Neuron**

Current Genetics 62: 347–370

VERD B.

**EvoDevo in Phase Space: The Dynamics of Gap Gene Expression**

Doctoral Thesis, Pompeu Fabra University, Barcelona



74 VERD B, CROMBACH A, JAEGER J.

**Dynamic Maternal Gradients Control Timing and Shift-Rates for *Drosophila* Gap Gene Expression**

PLoS Computational Biology

### 4.3 Forthcoming Publications

ALTENBERG L.

**Probing the Axioms of Evolutionary Algorithm Design**

Commentary on "On the Mapping of Genotype to Phenotype in Evolutionary Algorithms" by Peter A. Whigham, Grant Dick, and James Maclaurin

Programming and Evolvable Machines

ALTENBERG L.

**Genetic Information, Mutation Rates, and the Lore of the Error Threshold**

Proceedings of the 9th International Conference on Bioinformatics and Computational Biology (BICOB 2017)

ALTENBERG L, LIBERMAN U, FELDMAN MW

**Unified Reduction Principle for the Evolution of Mutation, Migration, and Recombination**

Proceedings of the National Academy of Sciences

ARNELLOS A.

**From Processes to Organisms and Other Biological Individuals**

In: Process Philosophy of Biology (Nicholson D, Dupre J, eds)

New York: Oxford University Press

ARNELLOS A, EL-HANI C.

**There Is Absolutely Nothing Brute in the Emergence of Biological Organizations**

In: Brute Facts Anthology (Vintiadis E, Mekios C, eds)

New York: Oxford University Press

BROOKS DS

**In Defense of Levels: Layer-cakes and Guilt by Association**

Biological Theory

BROOKS DS, ERONEN M.

**Levels of Organization in Biology**

Stanford Encyclopedia for Philosophy

BROOKS DS, ERONEN M.

**The Significance of Levels of Organization for Scientific Research:  
A Heuristic Approach**

Studies in History and Philosophy of Science Part C

CAZZOLLA GATTI R, HORDIJK W, KAUFFMAN S.

**Biodiversity Is Autocatalytic**

Ecological Modelling

DI COLA V, BROENNIMANN O, PETITPIERRE B, BREINER FT, D'AMEN M,  
RANDIN C, ENGLER R, POTTIER J, PIO D, DUBUIS A, PELLISSIER L, MATEO RG,  
HORDIJK W, SALAMIN N, GUIBAN A.

**Ecospat: An R Package to Support Spatial Analyses and  
Modelling of Species Niches and Distributions**

Ecography

DiFRISCO J.

**Biological Processes: Individuation, Criteria of Identity, and Persistence**

In: Process Philosophy of Biology (Nicholson D, Dupre J, eds)

New York: Oxford University Press

DiFRISCO J.

**Time Scales and Levels of Organization**

Erkenntnis

FISCHER B, MITTEROECKER P.

**Allometry and Sexual Dimorphism in the Human Pelvis**

The Anatomical Record

FISCHER B, FLECK M, SIMON UK

**Am Puls Biologie 5, Schulbuch für Biologie für die 5. Klasse Gymnasium**

Wien: Österreichischer Bundesverlag Schulbuch (oebv)



76 HORDIJK W.

**Autocatalytic Sets and RNA Secondary Structure**

Journal of Molecular Evolution

HORDIJK W, STEEL M.

**Chasing the Tail: The Emergence of Autocatalytic Networks**

BioSystems

KEIJZER F, ARNELLOS A.

**The Animal Sensorimotor Organization: A Challenge for the Environmental Complexity Thesis**

Biology & Philosophy

LANGE A, MÜLLER GB.

**Polydactyly in Development, Inheritance, and Evolution**

The Quarterly Review of Biology

MITTEROECKER P, HUTTEGGER S, FISCHER B, PAVLICEV M.

**Reply to Grossman: The Role of Natural Selection for the Increase of Caesarean Section Rates**

Proceedings of the National Academy of Sciences

MÜLLER GB. (ed)

**Vivarium – Experimental, Quantitative, and Theoretical Biology at Vienna's Biologische Versuchsanstalt**

Cambridge, MA: MIT Press

MÜLLER GB.

**Biologische Versuchsanstalt: An Experiment in the Experimental Sciences**

In: Vivarium - Experimental, Quantitative, and Theoretical Biology at Vienna's Biologische Versuchsanstalt (Müller GB. ed)

Cambridge, MA: MIT Press

MÜLLER GB.

**The Substance of Form: Hans Przibram's Quest for Biological Experiment, Quantification, and Theory**

In: Vivarium - Experimental, Quantitative, and Theoretical Biology at Vienna's Biologische Versuchsanstalt (Müller GB. ed)

Cambridge, MA: MIT Press

MÜLLER GB.

**Why an Extended Evolutionary Synthesis is Necessary**

Interface Focus

PETERSON T, MÜLLER GB.

**Developmental Finite Element Analysis (devFEA): A Quantifying Tool for the Study of Developmental Biomechanics Using Cichlid Pharyngeal Jaws**

PlosOne

PÉREZ-BEN C, SCHOCH R, BÁEZ AM.

**Miniaturization and Morphological Evolution in Paleozoic Relatives of Living Amphibians: A Quantitative Approach**

Paleobiology

SARTO-JACKSON I, LARSON DO, CALLEBAUT W.

**Culture, Neurobiology and Human Behavior:**

**New Perspectives in Anthropology**

Biology & Philosophy

SARTO-JACKSON I.

**Time for a Change: Topical Amendments to the Medical**

**Model of Disease**

Biological Theory

SHIRT-EDISS B, MURILLO-SÁNCHEZ S, RUIZ-MIRAZO K.

**Framing Major Prebiotic Transitions as Stages of Protocell Development: Three Challenges for Origins-of-Life Research**

Beilstein Journal of Organic Chemistry

VERD B, CLARK E, WOTTON KR, JANSSENS H, JIMÉNEZ-GURI E, CROMBACH A, JAEGER J.

**A Damped Oscillator Imposes Temporal Order on Posterior Gap Gene Expression in Drosophila**

Nature Communications

XENAKIS I, ARNELLOS A.

**Aesthetics as Evaluative Forms of Agency to Perceive and Design Reality: A Reply to Aesthetic Realism**

New Ideas in Psychology





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### **Volume 11, Issue 1:**

SARTO-JACKSON I, MACLEOD M, HANDSCHUH S, FRISCHER C, LANG J, SCHLUMPP M, CALLEBAUT W.

#### **A Piecewise Aggregation of (Some) Philosophers' and Biologists' Perspectives**

Essay Review on William C. Wimsatt: Re-Engineering Philosophy for Limited Beings: Piecewise Approximations to Reality

ARNELLOS A.

#### **Biological Autonomy: Can a Universal and Gradable Conception be Operationalized?**

Essay Review on Bernd Rosslenbroich: On the Origin of Autonomy: A New Look at the Major Transitions in Evolution

ZWICK M.

#### **Mind and Life: Is the Materialist Neo-Darwinian Conception of Nature False?**

Essay Review on Thomas Nagel: Mind and Cosmos: Why the Materialist Neo-Darwinian Conception of Nature is Almost Certainly False

AGOREN GC.

#### **Becoming Human, Together**

Book Review on Michael Tomasello: A Natural History of Human Thinking

BOLKER JA.

#### **Construction Sites: How Ecology Shapes Development**

Book Review on Scott F. Gilbert and David Epel: Ecological Developmental Biology: The Environmental Regulation of Development, Health, and Evolution

OLSSON L.

#### **The History of EvoDevo and the Influence of the 1981 Dahlem Workshop on Evolution and Development**

Book Review on Alan C. Love (ed.): Conceptual Change in Biology: Scientific and Philosophical Perspectives on Evolution and Development

SALTHER SN.

**What Actually is a Living System Materially?**

Book Review on Alvaro Moreno and Matteo Mossio: Biological Autonomy: A Philosophical and Theoretical Enquiry

**Volume 11, Issue 2:**

JELER C.

**Do We Need a New Account of Group Selection?**

**A Reply to McLoone**

SACKS B, MEYERSON G, SIEGEL JA.

**Epidemiology Without Biology: False Paradigms, Unfounded Assumptions, and Specious Statistics in Radiation Science**

BUSBY C.

**Some Comments on Sacks, Meyerson, and Siegel's Epidemiology Without Biology**

SCHMITZ-FEUERHAKE I.

**Commentary on Sacks, Meyerson, and Siegel's Epidemiology Without Biology**

BARBIERI M.

**From the Common Ancestor to the First Cells: The Code Theory**

BLUTE M.

**Density-Dependent Selection Revisited: Mechanisms Linking Explanantia and Explananda**

**Volume 11, Issue 3:**

IACOBAS DA.

**The Genomic Fabric Perspective on the Transcriptome Between Universal Quantifiers and Personalized Genomic Medicine**

NETO C.

**Rethinking Cohesion and Species Individuality**



80 REESE VR, FORSDYKE DR.

**Meiotic Pairing Inadequacies at the Levels of X Chromosome, Gene, or Base: Epigenetic Tagging for Transgenerational Error-Correction Guided by a Future Homologous Duplex**

SMIT H.

**The Transition from Animal to Linguistic Communication**

STERELNY K.

**Cumulative Cultural Evolution and the Origins of Language**

**Volume 11, Issue 4:**

HORDIJK W.

**Evolution: Limited and Predictable or Unbounded and Lawless?**

ALBERTAZZI L, LOUIE AH

**A Mathematical Science of Qualities: A Sequel**

DeJAGER J.

**Baldwin's Remarkable Effect**

WAGENSBERG J, WAGENSBERG M.

**The Collective Misunderstanding Syndrome**

WIEGMAN I.

**Angry Rats and Scaredy Cats:**

**Lessons from Competing Cognitive Homologies**

## 4.5 Scientific Presentations

ALTENBERG L.

### **The Deep Connection between Mutational Robustness and Mutational Time Dynamics**

Marc Feldman Research Group Meeting, Herrin Laboratories,  
Stanford University

ALTENBERG L.

### **Genes are Born Modular: Selective Filtering of Pleiotropy in De Novo Genes**

Bay Area Population Genomics Meeting BAGP-XIII,  
University of California, Berkeley

ALTENBERG L.

### **The Deep Connection between Mutational Robustness and Mutational Relaxation Time**

Nick Barton Research Group, Institute for Science and Technology  
Austria, Klosterneuburg

ALTENBERG L.

### **Lethal Mutagenesis Is Inescapable — But not due to Error Catastrophes**

Symposium on “Chemolution: From Chemistry to Evolution” dedicated  
to Professor Emer. Peter Schuster on the occasion of his 75<sup>th</sup> birthday,  
University of Vienna

ALTENBERG L.

### **Evolving NK Landscapes**

Dynamic Networks, Autocatalytic Sets, and Evolutionary Dynamics  
Complexity Science Hub Vienna

ARNELLOS A.

### **The Body Complexity Thesis: Multicellular Hurdles for Animal Cognition**

IAS-Research Centre for Life, Mind, and Society, University of the  
Basque Country, San Sebastian



82 ANDERSON WH

**Causation, Mechanisms, and Laws in Biology**

Workshop on the Integration of Mechanistic and Statistical Approaches to Evolution, KLI

BROOKS DS

**Joseph Needham's Contributions to the Levels Concept in Biology (1929-1945)**

International Society for the History of Philosophy of Science (HOPOS) Conference 2016, University of Minnesota

BROOKS DS.

**Commentary on Rudolf Stichweh "Sociocultural Evolution and Social Differentiation"**

Models of Change in the History of Science, Bielefeld University

BROOKS DS

**A New Look at Levels of Organization**

Philosophy of Science Association (PSA), Atlanta

BROOKS DS

**Nature as a Tool Box: A New Look at 'Levels of Organization'**

Re-Engineering Biology, University of Pittsburgh

BROOKS DS

**Fragmentary Means, Fragmentary Ends: Usage-based Continuity in Biological Concepts**

Colloquium for European Research Council (ERC) group "The Emergence of Relativism," University of Vienna

CAPEK D, MÜLLER GB.

**Avian Digit Identity in the Light of Digit Formation Models**

6th Meeting of the European Society of Evolutionary Developmental Biology, Uppsala

DiFRISCO J.

**Explanatory Idealization and Developmental Processes**

6th Meeting of the European Society of Evolutionary Developmental Biology, Uppsala

DiFRISCO J.

**Functional Explanation and Functional Equivalents**

Philosophy of Science Association (PSA), Atlanta

DiFRISCO J.

**Token Physicalism and Functional Individuation**

Society for Metaphysics of Science, Geneva

DiFRISCO J.

**Kinds of Biological Individuals: Projectibility, Analogy, and Selection**

University of Rijeka

DiFRISCO J.

**Functional Explanation and Functional Equivalents**

Nordic Network for Philosophy of Science, Pärnu

FISCHER B.

**Human Pelvis Shape, Stature, and Head Size Covary in a Way that Alleviates the Obstetric Dilemma**

Conference of the American Association of Physical Anthropologists, Atlanta

FISCHER B.

**Why Is Childbirth so Hard in Humans?**

Hearing for a Tenure Track Position in Anthropology, University of Vienna

FISCHER B, MITTEROECKER P.

**Allometry and Sexual Dimorphism in the Human Pelvis**

6th Meeting of the European Society of Evolutionary Developmental Biology, Uppsala

GIERLINGER N, MÜLLER GB, METSCHER B.

**Distribution, Morphology, and Development of Dental and Dermal Denticles in *Chiloscyllium* and *Scyliorhinus***

6th Meeting of the European Society of Evolutionary Developmental Biology, Uppsala

HORDIJK W.

**Autocatalytic Sets and the Organization of Life**

SysChem2016, Valtice



84 HORDIJK W.

**Autocatalytic Sets: The Origin and Organization of Life**

Gulbenkian Institute of Science, Oeiras

HORDIJK W.

**Autocatalytic Sets: The Origin and Organization of Life**

Pompeu Fabra University, Barcelona

HORDIJK W.

**Autocatalytic Sets: The Origin and Organization of Life**

University of the Basque Country, San Sebastian

JAEGER J.

**Beyond Networks: Dynamic Mechanisms for Developmental Processes**

Biotechnology Institute, University of Helsinki

JAEGER J.

**Everything Flows: Towards a Processual Perspective on Life**

Workshop, "The Nature of our Biophilic Universe," Rome

JAEGER J.

**The Best of Both Worlds? Reverse Engineering Regulatory Systems**

Philosophy of Science Association (PSA), Atlanta

JAEGER J.

**Beyond Networks: Dynamic Mechanisms for Developmental Processes**

Workshop "Networks in Biology," Göttingen

JAEGER J.

**Process Thinking for Evo-Devo: An Introduction**

6th Meeting of the European Society of Evolutionary Developmental Biology,  
Uppsala

JAEGER J.

**Life's Attractors: The Evolution of Dynamic Regulatory Networks**

Symposium on "Chemolution: From Chemistry to Evolution" dedicated to  
Professor Emeritus Peter Schuster on the occasion of his 75th birthday,  
University of Vienna



JAEGER J.

**Life's Attractors: A Dynamical Systems Perspective on Evo-Devo**

Eco-Evo-Devo Summer School, Oxford Brookes University, Oxford

JAEGER J.

**Life's Attractors: The Evolution of Dynamic Regulatory Networks**

COSB Seminar, University of Vienna

JAEGER J.

**Life's Attractors: The Evolution of Dynamic Regulatory Networks**

Workshop "Life Sciences & Simulation," MECS, Lüneburg

JAEGER J.

**Life's Attractors: The Evolution of Dynamic Regulatory Networks**

MPI-CBG, Dresden

JAEGER J.

**Shift Happens: The Evolutionary and Developmental Dynamics of the Gap Gene Network**

Vienna BioCenter Recess, Schloss Hernstein, Vienna

JAEGER J.

**Life's Attractors: Systems Biology in Evo-Devo**

Eco-Evo-Devo Graduate Module, IGC, Oeiras

JAEGER J.

**Life's Attractors: The Evolution of Dynamic Regulatory Systems**

Workshop on Evolutionary Systems Biology, Hinxton

JAEGER J.

**Life's Attractors: The Evolution of Dynamic Regulatory Networks**

Natural History Museum, London

LANGE A, MÜLLER GB.

**A History of Polydacty in Development and Evolution**

6th Meeting of the European Society of Evolutionary Developmental Biology, Uppsala



86 METSCHER B, MÜLLER GB.

**MicroCT Imaging for EvoDevo: 3D Embryos, Digital Beasties, and Virtual Museums**

6th Meeting of the European Society of Evolutionary Developmental Biology,  
Uppsala

MÜLLER GB.

**Evolving Evolutionary Theory**

Doktoral Program The Sciences in Historical, Philosophical and Cultural Contexts,  
University of Vienna

MÜLLER GB.

**EvoDevo and the Mechanisms of Evolutionary Innovation.**

Linking Evolution and Development of the Auditory System,  
Hanse Wissenschaftskolleg, Delmenhorst

MÜLLER GB.

**Core Theoretical Issues of EvoDevo: Biased Variation, Non-linear Transition, Emergent Novelty**

6th Meeting of the European Society of Evolutionary Developmental Biology,  
Uppsala

MÜLLER GB.

**Evolutionäre Medizin und die erweiterte Synthese der Evolutionstheorie**

Universitätsklinikum Freiburg

MÜLLER GB.

**Creative Development and the Extended Evolutionary Synthesis**

Creativity and Evolution. Games, Language, Robots, Life, Art  
Lake Como School of Advanced Studies, Como

MÜLLER GB.

**The Extended Evolutionary Synthesis**

New Trends in Evolutionary Biology: Biological, Philosophical, and Social Science  
Perspectives, The Royal Society, London

MURILLO-SÁNCHEZ S.

**On the Origins of Biomembranes: A "Systems Chemistry" Approach to Investigate Protocell Development**

Systems Chemistry COST Winter School, KLI, Klosterneuburg

PEREZ BEN C.

**Miniaturization and Paedomorphosis in Temnospondyl Amphibians**

European Association of Vertebrate Palaeontologists Meeting. Haarlem

PEREZ BEN C.

**Miniaturization and Paedomorphosis in Temnospondyl Amphibians**

6th Meeting of the European Society of Evolutionary Developmental Biology, Uppsala

PETERSON T, MÜLLER GB, BOWSHER J.

**Finite Element Analysis of Abdominal Appendage Development in the Sepsid *Themira Biloba***

6th Meeting of the European Society of Evolutionary Developmental Biology, Uppsala

SARTO-JACKSON I.

**Characterization of Amino Acid Residues in Loop E of GABA(A) Receptor Gamma2 Subunits and Their Role in Imidazobenzodiazepine Binding**

10th Forum of the Federation of European Neuroscience Societies, Copenhagen

SARTO-JACKSON I.

**Neuroscience and Social Pedagogy: Chances and Limits of an Interdisciplinary Approach**

33rd FICE Congress and 2nd CYC World Conference, Vienna

SARTO-JACKSON I.

**Fragility, Robustness, and Antifragility of Biological Neural Networks**

Middle European Interdisciplinary Master Programme in Cognitive Science, University of Vienna

SCHAEFER K, WINDHAGER S, MÜLLER GB, MITTEROECKER P.

**Prenatal Androgen Exposure: Effects on Human Facial Shape and its Perception**

6th Meeting of the European Society of Evolutionary Developmental Biology, Uppsala

VERD B.

**A Damped Oscillator Governs Posterior Gap Gene Patterning in *Drosophila melanogaster***

11th Physics of Living Matter, Cambridge



88 VERD B.

**Short and Long-Germband Segmentation Are not that Different**

6th Meeting of the European Society of Evolutionary Developmental Biology,  
Uppsala

VERD B.

**A Damped Oscillator Governs Posterior Gap Gene Patterning in  
*Drosophila melanogaster***

Evolutionary Systems Biology: From Model Organisms to Human Disease,  
Wellcome Trust Genome Campus, Hinxton, UK

VERD B.

**A Damped Oscillator Governs Posterior Gap Gene Patterning in  
*Drosophila melanogaster***

10th European Conference on Mathematical and Theoretical Biology,  
University of Nottingham

WINKLER V, MÜLLER GB, METSCHER B.

**Pelvic, Pectoral, Median: The Developmental Basis of Fin Evolution**

6th Meeting of the European Society of Evolutionary Developmental Biology,  
Uppsala



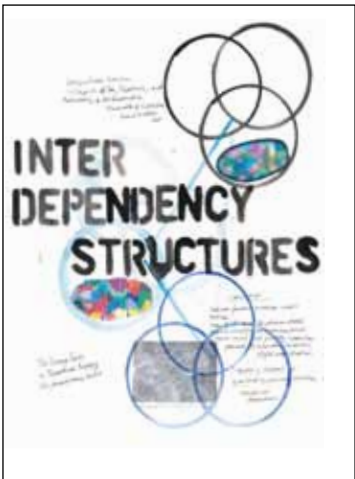
## Further Activities

5



*Many activities of the KLI exceed the scientific core agenda. Some representative activities are listed here.*

5.1 Arts & Science Events



Interdependency –  
How to Picture Living Systems

26 April 2016

KLI Klosterneuburg  
Curator: Petra Maitz

Topic

Art functioning as an aesthetic and shape-giving basis can contribute to modelling of epistemic objects in science. In which way can a model or a drawing be used to transfer knowledge or to generate knowledge? Drawings in art and in science can provide radically new insights.

The artist Petra Maitz presents special objects at the interface of art and science in this event. In her talk, she highlights the artistic challenges associated with it, but also the “light-bulb” experiences and achievements that come with the interdisciplinary nature of such projects. She discusses chances and aims of such cooperations with fellows of the KLI.





**How to Picture Living Systems 1**  
**24 October 2016**

*KLI Klosterneuburg*  
*Curator: Petra Maitz*

**Topic**

Opening:  
Round table discussion with Peter Schuster (University of Vienna), Gert Hasenhütl (Academy of Fine Arts), and Martin Walde (artist), moderated by Petra Maitz

Exhibition: 24.10.2016 - 31.1.2017  
Invited artists are: Peter Weibel, Martin Walde, Mariateresa Sartori from Italy, John Aslanidis from Melbourne, Australia and Irena Lagator from Montenegro.

Their works of art were selected by curator and artist Petra Maitz, because they deal implicitly with the topic of system description of natural processes and raise questions that allow a critical analysis of science with respect to a “right” and “wrong” epistemological foray. Today, the modus of aisthesis has again become a category of observing in teaching, and thus works of art mean an appreciable importance in scientific methodology.

Peter Weibel’s ENJOY YOUR DNA-films, Martin Walde’s HALLUCIGENIA products and Mariateresa Sartoris’ THE REASONS OF SCIENCE-film are variations of artworks that approach scientific questions. In arts, creation of forms and theses-backgrounds develop independently of scientists and establish a domain of interactions between both sides. This conception is illustrated by the present exhibition of international artists at the KLI, where the baroque mansion meets the modern extension. In this quasi-passage zone, a dialogue between art and scientific questions will originate – in a way how it was always traditionally discussed in a philosophical ambience in Austria.



**Ein musikalischer Abend  
„Die Graugänse fliegen wieder“  
25 May 2016**

*KLI Klosterneuburg  
Musik: Franz J. Mach*

**Programm**

SONATE FÜR GRAUGÄNSE

Am Ufer  
Im See  
Brautschau  
Fernweh  
Abflug

FRÜHLINGSNACHT

Notturmo  
Morgensonne  
Erwachen

GLÜCKLICHE JAHRE

Zirkusclown  
Im Tiergarten  
Ersehnte Nachricht  
Sommernacht

BEWEGTE TRÄUME

Sandmännchen  
Meerjungfrau  
Flaschengeist

Violoncello: Ingmar Beck  
Flöte: Amina Anna Vámosi  
Klarinette: Alexey Mikhaylenko  
Saxophon: Benedikt Gáspár  
Fagott: Ángela Valera Casanova  
Klavier: Hemma Tuppy  
Leitung: Ingmar Beck



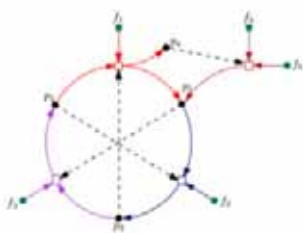
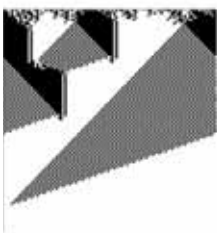
**The Art & Science of Nature**  
**1 July 2016**

*KLI Klosterneuburg*  
*Wim Hordijk*

**Exhibition**

Nature inspires us all with its seemingly infinite beauty and diversity. And not only is it a pleasure to simply enjoy natural beauty of this world, but also to try and understand the basic (and often very mathematical) principles that give rise to it.

During his career, Wim Hordijk has enthusiastically combined these two passions. Trained as a computer scientist, he has worked in many places all around the world, on various research projects aimed at understanding more about how nature works. Collaborating with biologists, physicists, chemists, and mathematicians, he has applied his computational skills to gain a better understanding of some of the basic principles of life, and to create computer simulations of natural systems based on these principles.



Next to study nature, he has also intimately connected with it by going on numerous hiking trips. Seeking solitude, and deliberately leaving his computer behind on a regular basis, Wim has explored (on foot) the mountains, forests, deserts, and coastlines of the many countries and regions he has lived and traveled in.

The results of both these passions are now combined in a exhibition entitled “The Art & Science of Nature.” For ten of the countries where Wim has lived and worked, non-technical and easy to understand one-page stories provide some interesting facts and viewpoints about life, natural systems, and science, based on the research projects he worked on in each of those countries. And these “scientific tidbits” are accompanied by beautiful photos of the natural environment of each country, taken on his many hiking trips. This way, the exhibition combines in both, an entertaining and an educational way the art and science of nature.

5.2 Public Outreach Activities



Long Night of Research  
22 April 2016

*IST Austria, Klosterneuburg*

*Organization: State Government  
of Lower Austria*

The KLI participated in the “Long Night of Research 2016” that was organized by the Office of the State Government of Lower Austria. The “Long Night of Research” is a nation-wide event that is funded by the Federal Ministry of Science, Research and Economy and the Ministry for Transport, Innovation and Technology, and supported by the Federal Ministry of Education and Women’s Affairs. It is dedicated to popular science and fun learning and aims at informing the Austrian public about what research does for society.



**Science Fair**  
**30 May 2016**

*Schloss Grafenegg*

*Organization: State Government  
of Lower Austria*

The initiative Science Fair is organized by the Office of the State Government of Lower Austria and fosters collaborations between research institutions and schools in Lower Austria. The closing event of the Science Fair took place at the equestrian school of the castle Grafenegg where 15 research institutions presented their work. The event was attended by more than 600 pupils and students.



**KLI YouTube Channel**  
**Launch Night**  
**23 June 2016**

*Klosterneuburg*  
*Producer: Gregory Boyle*

At this KLI Special Event, a series of short video portraits by Gregory Boyle were presented. Each movie portrayed a KLI fellow, his/her project, and the reason why he/she chose to work at the KLI. From the interviews and visuals in the movie, viewers got a sense of the interdisciplinary research community at the institute and the highly creative working environment. All movies can be found on the newly launched KLI Youtube channel at:  
[https://www.youtube.com/channel/UCN\\_n5b0\\_SKVohc1\\_B0T84mg](https://www.youtube.com/channel/UCN_n5b0_SKVohc1_B0T84mg)



## Höfefest 10 September 2016

*Klosterneuburg*

At the Höfefest 2016, the KLI opened its gates for the citizens of Klosterneuburg. On the premises of the KLI, guests could enjoy music performances, an exhibition of KLI-associated artists, a literary reading, and delicacies of the local cuisine.

### Program

JACOB & THE RIVER TOWN SOULS

**Folk, Covers und Eigenkompositionen**

DIETMAR GRIESER

**Lesung „Geliebtes Geschöpf - Tiere, die Geschichte machten“**

Concilium Musicum Wien

CHRISTOPH ANGERER (Violine, Viola d'amore und Moderation) &

UTE GROH (Violoncello)

**Musikalische Raritäten für Violine, Viola d'amore und Violoncello**

MONIKA KALLAUSCH

**Songs, die unter die Haut gehen**

Ausstellung mit Arbeiten von:

MARIO WESECKY

GRETE BLÜML

PETRA MAITZ

WIM HORDIJK

FELIX SCHOLZ

KLAUS STIEFEL



98 Impressions of the “Höfefest”



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