23rd ALTENBERG WORKSHOP IN THEORETICAL BIOLOGY

Scaffolding in Evolution, Culture, and Cognition

organized by

Linnda Caporael, James Griesemer, and William Wimsatt

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Konrad Lorenz Institute

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The topic and aims

Traditionally, scaffolding refers to the temporary system of platforms and poles erected for workmen to build or renovate buildings. It has also been used by educators and child psychologists to refer to the assistance that a more experienced person offers to a novice acquiring a new skill or performing a new task. The goal of this workshop is to examine examples of scaffolding to further expand the concept so as to shed light on institutions, face-to-face groups, and individuals connecting generations in evolutionary, cognitive, and cultural domains. Participants from diverse specialties will present and discuss their research on science, technology, and infrastructure, individual and group cognition, identity, skill development, practice, embodiment, group formation, reproduction, and ecological affordances. We seek phenomena and perspectives that integrate evolution, cognition, and culture across generations, ontogenies, intellectual histories, and wherever scaffolding is essential to the production of structures and processes, including those that themselves serve to scaffold. We begin with three interlocking perspectives—scaffolding to provide initial structure for the broad reach of this interdisciplinary workshop. The first perspective concerns reproductive and developmental systems (whether they are genes, bodies or institutions) that are constituted by the material overlap of physical parts that create the phenomena of inheritance between generations. The second concerns face-to-face group structures, co-constituted by group size and task, which inform the evolution, development, and operation of uniquely human social-cognitive systems. The third is the evolutionary accumulation, or generative entrenchment, of down-stream events and processes—complexes of biology, cognition, culture, and institutions generating differential rates of stasis and change at each of the genetic, developmental, and cultural levels.

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Scaffolding in Evolution, Cognition, and Culture

Thu 8 July	Evening	
6.00 pm		Welcome reception and dinner at the KLI

Griesemer explores a "reproducer" approach to general questions about units of evolution, cultural change, and how the approach articulates with Wimsatt's on generative entrenchment and Caporael's on repeated assembly of core configurations of humans. In discussing concepts from all three perspectives, Griesemer initiates the conversation with some cross-cutting ideas to address the wide range of models, cases, and perspectives that will be presented and discussed in the workshop.

7:45 pm - 8:30 pm	J. R. Griesemer	Scaffolding Cultural Reproducers

Fri 9 July	Morning	Scope and Scale	Chair: Heintz

Wimsatt explores the generality and range of entrenchment in adaptive structures, and how that leads naturally to scaffolding structures in culture. Newman and Evans an-chor two extremes of scale for entrenchment and scaffolding, from mesophysics of cellular adhesion to the communication structures and shared assumptions within and between scientific disciplines, spanning the scope of our discussions.

9.30 am – 9.40 am		Announcements
9.40 am – 10.30 am	Wimsatt	Generative Entrenchment in Complex Adaptive Structures
10.30 am – 11.00 am	COFFEE	
11.00 am – 11.50 am	Evans	Communication and the Evolution of Cognition
11.50 am – 12:40 pm	Newman	Mesoscale Physics as a Scaffold for Metazoan Development and Evolution
12:40 pm – 2.00 pm	LUNCH	at the KLI

Fri 9 July	Afternoon	Generativity and Entrenchment	Chair: Li

These papers share in the generation of novelty. Stress scaffolds cognition for Lyon, and in the social-cognitive scaffold provided by groups (among other things) for Heintz and Theiner. As in the papers in the morning session, they also relate to generative entrenchment, but possibly on different scales of cognition—at the least, they challenge the notion of cognition as something that happens "inside the head."

2.00 pm –2.50 pm	Lyon	Stress in Mind: Response to Homeostatic Challenge as a Scaffold for the Evolution and Development of Cognition
2.50 pm –3.40 pm	Theiner	Thinking at the Cusp of Unity: From Extended to Group Cognition
3.40 pm – 4:10 pm	COFFEE	
4:10 pm – 5:00 pm	Heintz	The Generative Entrenchment of Conceptual Change
	Dinner	at the Heurigen "Mayer am Pfarrplatz"

Sat 10 July	Morning	Granularity and Reciprocality	Chair: Evans

Allen and Martínez have embodiment, artifacts (including symbolic) and cultural evolution themata. Their grain is different from Gerson's approach to cultural evolution as institutional changes, but any theory of individuals or institutions are reciprocally related repeated assemblies with the scaffolding depending on perspective. Typically, however, researchers focus on one perspective with the other tacitly assumed and "held constant."

9.30 am – 9.40 am		Announcements
9.40 am – 10.30 am	Allen	Symbolic Reasoning as Scaffolded Perception and Manipulation
10.30 am – 11.00 am	COFFEE	
11.00 am – 11.50 am	Martínez	The Co-evolution of Cognition and Culture: The Scaffolding Role of Artefacts
11.50 am – 12:40 pm	Gerson	Some Problems of Analyzing Cultural Evolution

12:40 pm – 2.00 pm	LUNCH	at the KLI

Sat 10 July	Afternoon	Reproduction and Development	Chair: Lyon

McElreath's social transmission modeling resonates with institutional approaches, and at the same time, connects the local (learning from parents) with the cultural (the spread of parasitic beliefs). It contrasts with Jablonka's novel extensions of Waddington's work as a more general description of reproduction-by-development (instead of transmission), in some sense, providing a response to issues of granularity in landscape, canalization, guy ropes, and pegs. Li, a developmentalist, asks for us to consider the brain as the scaffold between biological and sociocultual coevolution.

2.00 pm –2.50 pm	McElreath	The Co-evolution of Learning and Parasitic Ideas
2.50 pm –3.40 pm	Jablonka	The Reproduction of the Social: A Waddingtonian View
3.40 pm – 4:10 pm	COFFEE	
4:10 pm – 5:00 pm	Li	Brain Is also a Dependent Variable: Biocultural Co-Construction of Developmental Plasticity across the Lifespan
5.00 pm – 5:50 pm	Schank	Models as Scaffolds to Insight and Understanding
6.00 pm	Dinner	at the restaurant "Griechenbeisl"

Sun 11 July	Morning	Scaffolding: Reflections and Ambitions	Chair: Theiner

Murmann resonates with the future of scaffolding. He takes up the foundational concepts of the organizing paper, and shows how research in a number of areas of economics and management merit attention for their potential contribution to scaffolding in general. Thus, he spirals up and out from the beginning, which Caporael follows with a playful and collaborative commentary about groups and emergent workshop themes setting the stage for a discussion of goals for the edited book.

9.30 am – 9.40 am		Announcements
9.40 am – 10.30 am	Murmann	Scaffolding in Economics, Management, and the Design of Technologies
10.30 am – 11.00 am	COFFEE	

11.00 am – 11.50 am	Caporael	Of Groups and Goals
11.50 am – 12:40 pm	All	Participants Discussion
12:40 pm – 2.00 pm	LUNCH	at the KLI

Abstracts

JAMES R. GRIESEMER
Philosophy, University of California, Davis, USA

Scaffolding Cultural Reproducers

The parent-offspring relationship is one of material overlap not merely resemblance. Offspring (whether genes, cells, organisms, or social groups) are made from physical parts of the parents. Through material overlap, offspring are born organized into a context so as to have the capacity to develop, i.e., the capacity to acquire the capacity to reproduce. Material overlap, in contrast to mere information transmission, facilitates the robust propagation of generative mechanisms for repeated assembly of complex material reproducers. This material organization affords opportunities for generative mechanisms to become entrenched in evolution, as interactions with external environments that scaffold development become internalized as developmental relations among parts. My aim is a general account of evolutionary units in recurrent genealogical relationships suited to a theoretical landscape encompassing multi-level selection, multiple inheritance systems, multiple evolutionary transitions to new levels, and multi-way interactions between development, behavior, and environment.

Accounts of cultural evolution typically consider whether cultural systems satisfy principles of heritable variation in fitness. My question is not so much whether Darwinian models can be made to fit cultural phenomena but how best to discover cultural phenomena worth explaining in evolutionary terms.

I emphasize generative, developmental aspects of repeated assembly in reproduction processes rather than transmission of expressed states or properties. I seek a developmentalism that better expresses the entwined, integrated character of heredity and development than do theoretical perspectives that make

strong idealizing distinctions between germ and soma, genotype and phenotype, or replicator and vehicle. I return to Mendel's insight that "genetics" concerns the nature and pattern of development from hybrids (Griesemer 2007). By what mechanisms can heterogeneous elements of distinct lineages be hybridized so that development can not only proceed through complex morphogenetic transformations, but propagate developmental capacities to a next generation and repeat the assembly of successful reproducers? Mendel's solution appealed to "factors" stable in the development of hybrids, yet capable of producing patterns of variation among offspring. Weismann's solution appealed to sequestration of a cellular germ line. What, if any, analogous solution applies to higher levels?

How can repeated assembly of trait-groups of organisms occur despite their dissolution into a random mating pool each generation? How can demes stably develop to repeatedly express stable group traits despite exchanges of varying migrants? How can small human task groups, organized on the fly around ad hoc tasks, repeatedly assemble from among the same band of thirty or so humans, despite changing personnel with varying experiences? How can macrobands numbering in the hundreds, or modern industrial societies in the millions, persist in expressing stable but variable rituals, conventions, and institutions, despite exchange of varying individuals, bands, and even whole macrobands? How can collectives of people (or other sorts of individuals) belonging to multiple groups simultaneously develop stably but variably?

Scaffolding holds a key to this general problem of heredity-development. Bickhard (1992: 35) defines developmental scaffolding this way: ‘‘Functionally, scaffolding is precisely the creation of ... bracketed trajectories of potential development through artificially created nearby points of stability." My specific question is about how scaffolding works in the developmental context of hybrids at all levels of reproducer organization, i.e., how it is possible that hybridity creates conditions which constrain or enhance developmental possibilities while creating nearby points of stability such that variation can fuel evolutionary processes. How can development-environment interactions scaffold development? How can development evolve architectures of internal scaffolding? These are central questions for

a reproducer account of evolutionary units because development and its generative consequences are key to viewing reproduction as a process.

WILLIAM WIMSATT
Department of Philosophy and Committee on Evolutionary Biology, University of Chicago

Generative Entrenchment in Complex Adaptive Structures

Different parts and processes in any complex adaptive structure have different roles and diverse effects manifested in the development and maintenance of its structure and patterns. The generative entrenchment of an element is a measure of how many things depend upon it. More deeply entrenched parts would tend to be more conservative—to change less and in more restricted ways, with greater difficulty, or under more special conditions. These more entrenched elements should persist longer, yielding more chances to build upon or presuppose them in other constructions. Things that are particularly favored or robust—such as the stabler core configurations—should be incorporated more readily and widely, and appear as deeper architectural features as they are built upon. Particularly favored should be structures facilitating production of a combinatorial alphabet of components that can serve as parts in structures of diverse types and put to different uses. Symbols, machine tools, standardized parts, and programming languages fit here, but so also are assemblages of people who can self-organize or be organized by others into functioning teams to accomplish specialized tasks. Any populational account of cultural evolution requires a developmental structure for individuals (that scaffolds their acquisition of competencies), a population structure for institutionalized specialty groups (that structures this acquisition of competencies, through recruitment reproduces and maintains groups and specialties, and articulates institutions and social groups into the larger scale structures of culture). This articulates and scaffolds individuals, institutions, and organizations, as transgenerational structures, and each as potential reproducers. Core configurations should be differentially favored in these structures as more robust and functionally meaningful aggregations, and richly embedded in the larger structures of culture.

Finally, for constructing theory, developmental and maintenance dependencies, like the stabler core configurations, should have an advantage: they should be re-latively easily detectable.

Because differential entrenchment is a generic feature of complex adaptive systems, it arises throughout the range of evolved and constructed systems. I will try particularly to suggest how it might be found in the cellular systems of Stuart Newman, and also the larger scientific communication structures of Jim Evans.

JAMES A. EVANS
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Communication and the Evolution of Cognition

One central way in which social interaction scaffolds cognition is through communication. My talk will explore the role of communication and shared communication protocols including language, standards (e.g., shared measurements, container sizes, database schemas), networking (e.g., phone and Internet connections) and other media in shaping the cognitive institutions of knowledge and culture. I begin with a discussion of the influence of shared scientific languages on advance in science, but suggestively extend this to other such institutions like news, fashion, rumor, and religion, as also to nonhuman social systems (e.g. quorum sensing in bacteria).

Shared scientific language enables scientific advance by allowing more scientists to coordinate with one another and to efficiently organize around scientific problems. To the extent, however, that scientific language also facilitates the spread of axioms, values, frameworks, and methods, it advances science by narrowing the scope of problems considered. This second point is the central insight from Kuhn's *The Structure of Scientific Revolutions* (1962), and combined with the first suggests that more communicated agreement about how to do science leads necessarily to faster accumulation of scientific insight. Nevertheless, the more

axioms are multiplied within a scientific language and community, the less relevant resulting knowledge will be to researchers and problems outside it. In this sense, shared language nudges science to know more about less. This points to an apparent irony: that more complex problems will lead not to more divergent, but more convergent hypotheses as researchers rely on science agreements to make apparent progress.

In parallel, I will explore the influence of the structure of scientific communication on scientific advance. Nested, hierarchical structures facilitate efficient specialization in the context of an existing disciplinary framework, while inconsistently interconnected scientists enable interdisciplinarity and the spread of ideas from one domain to another. But social structures not only constrain and enable the flow of information. They act also as patterns that make homologous scientific ideas seem more plausible, and other ideas less so. In this sense, the outcomes of interdisciplinary science may be lauded in part because they increase the returns to scientific investment, but also in part because they mirror a valued system of cross-cutting communications structures.

I will subsequently compare and contrast the role of communication in scientific knowledge making with other institutions well beyond it.

STUART A. NEWMAN
New York Medical College Valhalla, New York USA

Mesoscale Physics as a Scaffold for Metazoan Development and Evolution

A naïve notion of evolution holds that organismal form can change in entirely arbitrary ways under appropriate selective regimes. On the contrary, experience tells us that particular classes of multicellular organisms – animals, fungi, plants – exhibit characteristic morphological motifs. The entire range of forms in any of these groups gives the appearance of being generated by what the architectural theorist Christopher Alexander (2002) calls a “pattern language.” This talk will

present the idea that the pattern language for animal form is constituted by a set of “dynamical patterning modules” (DPMs), associations of ancient gene products that had first evolved in single-cell organisms (King et al. 2008; Shalchian-Tabrizi et al. 2008) with physical forces and processes only relevant to the larger scale of multicellular aggregates (Newman and Bhat 2009; 2009). In this new context the DPM-related molecules (a subset of the “developmental-genetic toolkit”; Carroll et al. 2005), automatically took on novel functions in guiding the 2- and 3-dimen-sional arrangement of cells, enabling the rapid generation of complex forms with minimal change in gene sequence.

In this view the physics of mesoscale materials provides a scaffold for the organization of animal form (Forgacs and Newman 2005; Newman et al. 2006). This is distinct from the claim that animal embryos are merely mesoscale materi-als. They are clearly not–only the expression of certain genes permits cells to mobilize relevant physical forces on this scale. For example, cells need to ex-press surface adhesion molecules (e.g., cadherins) in order to form multicellular aggregates in the first place (Abedin et al., 2008). Such aggregates can become hollow or elongated by energy minimization if the individual cells become polarized in either surface composition or shape, both of which are induced by the Wnt biochemical pathway (Karner et al. 2006a,b). Energy minimization will also lead to tissue multilayering if cells reliably assume alternative states with respect to the expression of adhesion molecules (Steinberg 2007).

All cells, even unicellular organisms, have multistable dynamics due to the pro-perties of their internal gene regulatory networks (Lander 2009). What enables a multicellular cluster to maintain a balance of different cell types is the physical effect of lateral inhibition, which is mediated by the Notch pathway (Katsube and Sakamoto 2005). The secretion of mobile molecules (e.g., BMP, Shh), trans-ported by diffusion or related processes, permits the multicellular aggregate to develop chemical gradients, making it different from one end to the other (Lander 2007). Oscillation in internal chemical composition, a behavior potentially sus-tained by any cell (Reinke and Gatfield 2006), has the reciprocal effect, since the oscillations spontaneously and inevitably come into synchrony at the multicellular

level (Strogatz 2003; Garcia-Ojalvo et al. 2004), generating long-range coordination of cell state, i.e., morphogenetic fields (Gilbert et al. 1996). The interplay of gradients with synchronized oscillations or allied local autoactivation-lateral inhibitory circuitry (e.g., the reaction-diffusion mechanism of Turing 1952) can lead to the periodic or quasi-periodic arrangement of skeletal elements seen in the vertebrate backbone (Lewis et al. 2009) or paired limbs (Zhu et al. 2010).

The notion of mesoscale physics as a scaffold for the action of genes that mediate cell-cell interactions helps account for both the origination and entrenchment of animal form over the course of evolution (Wimsatt 1986; Müller and Newman 2005). As described above, the major morphological motifs arose early by mechanisms that were simultaneously plastic and stereotypical in their outcomes. This led to the “explosion” of body types seen at the Precambrian-Cambrian boundary more than half a billion years ago (Conway Morris 2006). Subsequent genetic change, without taking these multicellular systems outside of the morphospace defined by the physical scaffolding, integrated and consolidated the generation of their forms, ultimately arriving at the developmental programs of present-day animals.

PAMELA LYON
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Stress in Mind: Response to Homeostatic Challenge as a Scaffold for the Evolution and Development of Cognition

Organisms from bacteria to humans actively maintain themselves far from thermodynamic equilibrium by seeking out necessary resources to preserve system integrity (von Bertalanffy 1950) while simultaneously manufacturing the components that make all this possible (Maturana and Varela 1980). This is no mean feat. To date, no non-biological physical-chemical system, natural or contrived, comes close to accomplishing what organisms do unexceptionally, simply by existing (Lyon in press). Homeostasis is the state of dynamic systemic balance maintained by an organism's physiological organization and behavioural repertoire. Any state of affairs that challenges homeostasis presents a stress stimulus to the organism (Selye 1956). Threats to homeostasis are many and varied, are sometimes predictable but often not, and may come from outside the boundary that encloses the organism's autopoietic organization, or from within it. Every organism, no matter how simple, has a repertoire of physiological and behavioral processes to meet perturbations that it perceives as threatening to its survival (Storz and Hengge-Aronis 2000). Patterns of response that facilitate an organism's adaptation to homeostatic challenge are called stress responses.

In this paper I will argue that the response to homeostatic challenge is an important scaffold for the evolutionary development and elaboration of cognition. By this I mean that the existential urgency of anticipating and correctly apprehending a threat to survival, wellbeing or reproduction constitutes a vital parameter within which cognition has evolved and developed in many highly diverse phyla. Just as the same bamboo scaffolding used for building in India can support the construction of a multi-storey brick home, a Hindu temple or a corporate tower, the ever-present need to predict, perceive, and react to existential challenge has supported a staggering variety of responses across the living world, many of them cognitive.

To persist in its world, an organism arguably must have some means of ascertaining three general kinds of state (Lyon 2006a). First, it must be able to ascertain that its overall functioning is adequate, or acceptable (OK) in the current circumstances. Second, it must be able to ascertain that internal functioning and/or external circumstances are unacceptable or threaten persistence in some way; they are "not okay" (OK-). Finally, there must be a means of moving the system from a low baseline of acceptability—say, following recovery from insult or threat—to a more optimal level of functioning, that is, a means of ascertaining that conditions are pretty good and enhancement is possible (OK+). A stress response can be viewed as the organism's pattern of reaction to a perception that something, either within itself or in its surrounding milieu, is OK-. The stimulus may be life-threatening or merely perturbing, it may be a lack of or the presence of something, but it is sensed as challenging the organism's current set-point for adequate functioning and thus is perceived as a stressor. As researchers studying cardiovascular disease have observed, "humans reacting to stressors, which are not life-threatening but are 'perceived' as such, mount similar stress/inflammatory responses" (Black and Garbutt 2002: 1).

My central claim is that a major purpose of any organism's capacities for sensing aspects of its external milieu and processing information from multiple sources is to identify whether current circumstances are OK, OK-, or OK+—but especially whether they are OK-, a state of affairs demanding immediate physiological and/or behavioral counter-measures. Because a scaffold is not a ratchet that allows movement in only one direction, this doesn't mean that in response to threat all species will "get smart" over the course of their evolution. Hardly. Other defensive options include body armor (e.g., turtles, armadillos, porcupines, echidna), a nasty taste or smell (e.g., skunk), and toxic glands or skin (e.g., cane toad). How-ever, there is ample evidence to suggest that many organisms, even very simple ones, do become more behaviorally and cognitively sophisticated in response to homeostatic challenge.

By cognition I mean the suite of sensory and information-processing capacities an organism has for becoming familiar with and successfully exploiting its environment in order to meet internally generated goals, the most basic of which are survival, well-being, and reproduction. This is a biogenic definition of cognition (Lyon 2006b), i.e., a definition grounded in the principles of biology—what organisms do to make a living—rather than in intuitions derived from the peculiarities of human experience, which in my terminology constitutes an anthropogenic approach, the approach most commonly adopted in the cognitive sciences. My approach to the concept of "stress response" is also biogenic. It is grounded first and foremost in the features of biological stress responses and how they operate, including in human physiology and psychology, rather than in ordinary meanings of what it is to be "stressed."

Drawing on current psychological and neurobiological literature, the paper will examine two cognitive phenomena—novelty-seeking/curiosity and decision making—in light of the central thesis.

GEORG THEINER
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Thinking at the Cusp of Unity: From Extended to Group Cognition

Within the situated cognition movement, thinking is often considered as a form of intellectual niche construction—an activity in which cognitive agents generate, appropriate, and integrate material and social-cultural resources of their environment ("scaffolds") into their pre-existing cognitive structures, and thereby reconfigure the capacities which those structures enable (Wilson and Clark 2009; Robbins and Aydede 2009). If the interactions between brain, body, and environment are sufficiently dense and functionally integrated in the context of cognitive activities, it becomes increasingly arbitrary to single out the contributions of the body or the external world as mere "inputs" or "instruments" for cognition. In this case, or so the argument goes, the mind itself extends beyond the head into the

world (Clark 1997, 2003, 2008; Clark and Chalmers 1998; Wilson 1995, 2004; Rowlands 1999, 2006; Menary 2007).

While recent treatments of the "extended mind" thesis have focused predominantly on the cognitive effects of people's interactions with artifacts, interactions among people are another promising place to look for extended cognition. In this talk, I draw on the notion of cognitive extensions to argue that groups can form cognitive systems in their own right, capable of having emergent cognitive capacities that are not possessed by any of their members (see also Theiner 2008; Theiner, Allen, and Goldstone forthcoming). My discussion is grounded in three principal considerations that have been put forth in favor of extended cognition, but suitably modified to buttress our case for group cognition.

First, I show how the concept of an epistemic action (Kirsh and Maglio 1994), which traditionally refers to ways in which individual agents modify their material environment to improve their cognitive performance, can also be used to understand the many ways in which people modify their social interactions to cope with the challenges of thinking together as a group. Second, I propose an analogical extension of Clark and Chalmers' (1998) principle of parity dubbed social parity: if, in confronting some task, a group collectively functions in a process which, were it done in the head, would be accepted as a cognitive process, then that group is performing that cognitive process. To clarify the application of social parity, I carefully map out the inferential roles it is supposed to play in arguments for group cognition, and illustrate the suggested reasoning with research on group memory. Third, I explore the question under which conditions we can justifiably treat a group as a distributed cognitive system ("unit") in its own right, and the explanatory value of such an analysis. I argue that some of the most potent forms of human group cognition are situated somewhere between the relative cognitive autonomy of individual human organisms and the collective intelligence of social insects—in a region reserved for "thinking at the cusp of unity."

CHRISTOPHE HEINTZ

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The Generative Entrenchment of Conceptual Change

The literature on conceptual change, in the history and philosophy of science, has mainly focused on the selection processes rather than the generative processes. New concepts find their way in science by replacing previous concepts and the question is then why some new concepts are preferred to past ones. Answers have tended to disconnect the context of justification, as the selective process, from the context of discovery, as the generative process. This move is somewhat similar to the one made by the modern synthesis in evolutionary biology, which focused research on selection. In such a perspective, the generation of novelty is mainly described as being blind and the developmental processes are viewed as of little relevance to evolution. But EvoDevo, in evolutionary biology, and Sperber's epidemiological approach in the study of cultural evolution, have both emphasized, in their respective domains, the importance of studying the generative processes of variation and similarity. A point made by Wimsatt is that the generative processes must always draw on already existing resources, even when what is generated is novel: variations as well as similarity are generatively entrenched.

Conceptual change is semantically characterized as the production of new concepts that are not compositions of old ones. One may therefore feel that there is something odd in questioning the generative entrenchment of conceptual change: traditional views on conceptual change, indeed, have either denied that it exists, arguing that all concepts must be composed of already existing one (the Fodor-ian view), or have emphasised incommensurability to a point that entrenchment is denied: conceptual change comes from a rejection of past concepts; there is, rather, a kind of gestalt switch (the Kuhnian view).

Yet, cognitive scientists Nancy Nersessian and Susan Carey have provided an account of conceptual change that specifies the cognitive processes at work. Carey talks of Quinian bootstrapping: a placeholder structure (e.g., the counting

routine) is provided meaning through its relation among external symbols, partial interpretations, modeling processes, and inductive steps. The placeholder structure thus comes to combine distinct representational resources and taps in several inferential mechanisms. Nersessian specifies the role and aspects of the modeling processes—which include making analogies, thought experiments, and the exploitation of aspects of external representations. Explaining these generative processes enable specifying the resources drawn upon, and thus the entrenchment of conceptual change. Carey shows the entrenchment of children's conceptual change in their innate systems of "knowledge" and inference (core knowledge), and Nersessian shows the entrenchment of scientists' conceptual change in previous scientific theories and practices (e.g., Maxwell and fluid mechanics).

In my talk, I will present Carey's and Nersessian's work as explaining the generative entrenchment of conceptual change: I will therefore make use of Wimsatt's notion at the infra-individual level, hopefully contributing to our understanding of cognitive processes that are at the origin of major cultural changes. I will furthermore complete Carey and Nersessian's account with a specification of the social cognitive abilities that enable conceptual change: such abilities, indeed, enable children and scientists a stance where they hold as useful and truth-conducive representations that they do not (yet) fully understand. I will argue that, as social cognition is fully at work in conceptual change, the entrenchment is on the knowledge and practices of a community rather than just on the individual resources of the person undergoing conceptual change. Finally, I will draw a picture of conceptual change as the reflexive systematic recruitment of cognitive resources for solving some new types of problems.

COLIN ALLEN
History & Philosophy of Science, Indiana University, USA

Symbolic Reasoning as Scaffolded Perception and Manipulation

Note: This abstract is from David Landy, Colin Allen, & Carlos Zednik, in prep., “A perceptual account of symbolic reasoning.” My talk will cover that paper and add a few thoughts about cognitive evolution in light of the theory.

People can be taught to manipulate symbols according to formal mathematical and logical rules. Cognitive scientists have traditionally viewed this capacity—the capacity for symbolic reasoning—as grounded in the ability to internally represent numbers, logical relationships, and rules in an abstract, amodal fashion. Much of the debate around formal reasoning has centered on whether formal systems are internally represented and processed via inferential rules, or whether situations are represented semantically and conclusions read off an internal model.

In this paper, we build on ideas from embodied and embedded cognitive science to develop and defend a different kind of theory, in which arithmetic and logical formulae, externally represented as notations, serve as targets of powerful perceptual and sensorimotor systems. Formal reasoning often occurs through interaction with an external public notation; perceptual motor processes acting on that notation are responsible for problem solutions. We propose that abstractions in math and logic are understood primarily through manipulating external symbolic systems. On this view, formal reasoning does not happen through internal recursive structures, but arises as a result of trained perceptual-motor interactions with a congenial notation. We distinguish “translational” accounts, in which the cognitive action of problem solving happens within a reasoning system, from “non-translational” accounts such as ours, in which the conversion from an external stimulus to representational codes—perception—itself simplifies and partially performs the task of solving formal mathematics and logic problems. Although symbolic reasoning often conforms to abstract mathematical principles, it is implemented by perceptual and sensorimotor interactions with concrete environmental structures.

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The Co-evolution of Cognition and Culture:
The Scaffolding Role of Artefacts

I will review several accounts of embodied cognition and point to an implicit claim in such accounts, the idea that cognition and culture have to co-evolve. The central aim of this paper is to argue for the importance of artefacts as scaffoldings for such co-evolution. This will require getting clear on different notions of scaffolding and affordance and in particular it will require getting clear on the specific sense in which affordances in the sense of Gibson can be generalized to a social setting. Artefacts scaffold cognition as irreducible social cognition grounded in affordances that can be identified with stable configurations of practices. Such a notion of affordance is largely compatible with notions of affordance discussed in robotics and ecological psychology. Nonetheless, I want to argue for accounts of scaffolding and affordance that require an understanding of the normative dimension of what is considered the right use of an artefact as a sort of constraint on the co-evolution of cognition and culture. I will do this by introducing and arguing for the importance of what I call artifact-representations. Such representations capture an important sense in which "history matters" for the co-evolution of cognition and culture. The sense in which "history matters" is related to the fact that artefacts are deeply generatively entrenched in cognition and culture.

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Some Problems of Analyzing Cultural Evolution

The study of "cultural evolution" is concerned with two overlapping but separate topics: understanding the emergence of culture as a (possibly unique) character

of *Homo sapiens* as a problem in hominid biology, and understanding how culture changes. This essay considers a number of conceptual and theoretical problems with current approaches to the second topic, and suggests some directions for further research.

The first conceptual problem is the perennial one of defining culture. There are four classes of definition for the notion of culture, each oriented to different concerns. I adopt a view that construes culture as a system of institutions or conventions, i.e., patterns of conduct jointly produced and reproduced by interacting participants. These patterns are conducted by concrete groups and organizations, whose performances vary from time to time and place to place. An institution is thus a collective capacity to perform a group of related tasks.

A second major problem is the way in which cultural change or evolution is conceptualized. It is often suggested that there is continuity or a useful analogy between Darwinian evolution (i.e., biological speciation via reproductive isolation and natural selection) and cultural change or evolution. There are many difficulties associated with this view. A third conceptual problem is the need to focus on actual mechanisms of institutional change in order to understand cultural evolution. Institutional change routinely takes place via addition, modification, and deletion of constituent conventions. The existence of simple law-like regularities in this process is problematical. The changes created by copying-and-tinkering, abstracting-and-analogizing, and other change processes are enabled, limited and shaped: (1) by variations in repeated assembly as institutions are recreated in new times and places; (2) by scaffolding as organizations and institutions support one another; and (3) by generative entrenchment as new developmental dependencies among institutions emerge over time. Understanding the relation-ships among these processes (and others yet to be described) is a major challenge to the next generation of the social sciences.

RICHARD MCELREATH

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The Co-evolution of Learning and Parasitic Ideas

The social transmission of behavior is no doubt an adaptation. However, once social learning from people other than one's parents evolves, it may favor the evolution of "parasitic" beliefs that channel individual resources that could be spent on survival and reproduction into spreading the belief itself. These dynamics in turn induce new selection pressures on the nature of social learning, such that observed social learning strategies may not be understandable without accounting for the dynamics that social learning itself creates. In this paper, I model this narrative, the evolution of a preference for learning from parents, when parasitic beliefs are possible. Learning from parents can inoculate both the individual and the population from the rise and spread of parasitic ideas, sometimes resulting in the stability of vertical learning even when learning from non-parents would otherwise be favored by natural selection. This complex dynamic is an example of how the evolution of a transmission mechanism results in novel evolutionary dynamics that in turn alter the nature of the transmission.

IDDO TAVORY, The New School for Social Research, USA
EVA JABLONKA, Tel Aviv University, Israel
SIMONA GINSBURG, The Open University, Israel

The Reproduction of the Social: A Waddingtonian View

In this talk we introduce a framework developed for thinking about the social dynamics of recurring social states, inspired by Waddington’s epigenetic landscape model and his notion of developmental canalization. Although there are profound differences between Waddington’s embryological dynamics and the social dynamics that sociologists explore, there are some similarities: in both cases, from an array of contingencies and interacting processes a relatively coherent complex of recurring phenomena emerges.

Waddington's schema assumes that any stable, recurring, end-state is the effect of a dynamic network of processes. According to his scheme, a large number of interacting factors tend to co-regulate and co-scaffold each other in ways that produce a recurring end-point. Although there could be many variations in the specific initial conditions and the trajectories leading to the end point, the end-state is relatively stable. Like Waddington's epigenetic landscape model, our model describes the dynamics of processes as a pattern of interactions among underlying pegs sporting guy ropes, which support an overlaying landscape. The regulatory structure of these interactions raise the chances that a particular end point (a particular social situation or state) will recur, so that even if one of the pegs changes or disappears altogether, and even when the landscape paths' changes, the same end-state is reached.

Like Waddington, we assume that there is very rarely, if ever, a situation in which a recurrent state of affairs is underlain by one causal process. A change in the end state usually requires multiple changes in the underlying "pegs" either through a cumulative process of changes over a long time, as a result of a large change that simultaneously changes many pegs and guy ropes, or through a change in one or few "fragile sites" which have multiple downstream effects and therefore allows the system to reach a new end point. Our focus is therefore on understanding the dynamic stability of socio-cultural phenomena, seen as a result of interrelated patterns of "plasticity" and "canalization" operating at different levels of organization and working through different co-regulating mechanisms.

We define the key concepts developed within this framework, show where our use of the landscape metaphor departs from Waddington's, and discuss its application for the understanding of cultural processes by focusing on two cases – the reproduction of poverty, and the reproduction of religious life in a Jewish American Orthodox neighborhood in Los Angeles. We argue that our framework is a useful heuristic for mapping the relationships between different types of processes and the social fabric that emerges through their interaction.

SHU-CHEN LI
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Brain Is also a Dependent Variable: Biocultural Co-Construction of Developmental Plasticity across the Lifespan

This presentation reviews the emerging trend of interdisciplinary research aiming at exploring the effects of socio-cultural influences on human brain functioning. Recent co-constructive theories of brain and cognitive development as well as empirical evidence of developmental plasticity at different levels will be the central themes. Specifically, the talk will build upon multiple levels of empirical evidence to contend that brain is a dependent variable that could be shaped, scaffolded by learning and other socio-culturally contextualized experiences. The first set of examples will focus on brain plasticity in the sensory and motor cortices as an adaption to environmental inputs and professional expertise. The second cluster of evidence will highlight brain plasticity in memory and other cognitive functions as the results of cognitive interventions and cultural differences. Using memory plasticity as a showcase, the rest of the talk will integrate multiple levels of evidence to track the scaffolding effects of culturally derived mnemonic training on (i) memory performance, (ii) brain functional circuitries supporting memory functions, and (iii) the neurotransmitter systems that modulate these brain networks. Extant empirical evidence of developmental plasticity at different levels presents a warning against the “purely reductionist approach” to the genetic and neuronal bases of mind and behavior that ignores the influences from cultural, experiential, and cumulative developmental contexts. The reason is clear: genetic activities and neural mechanisms themselves possess remarkable plasticity awaiting socio-cultural contexts to exert reciprocal influences on them and to be the “co-authors” of mind and behavior. People are more than mere biol-ogical organisms; human mind and behavior need to be understood by situating them properly within a brain in a body that lives in an eventful world abounding with objects, other creatures, and *sapiens* colleagues.

JEFFREY SCHANK
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Models as Scaffolds to Insight and Understanding

One of the most perplexing problems faced by modelers in any area of science is how unrealistic models can provide insight and understanding into complex systems. All models are unrealistic in many respects and, indeed, they must be unrealistic in some respect to function as tools for insight and understanding. The problem is to show how at least some unrealistic models can lead to insight and understanding. I do not have a general theory about how unrealistic models lead to insight and understanding of complex systems, but I will illustrate some of the characteristics of unrealistic models that allow them to provide insight and understanding with the help of examples. Of particular importance is that insight and understanding comes from model building processes in which models are analyzed, tested, compared, discussed, revised, discarded, and rebuilt. It is in the context of model building processes in which models are revised, discarded, or rebuilt that modelers build insight and understanding from the scaffolding models provide (both sound and faulty). I will illustrate this by discussing some agent-based models of the evolution of cooperation. If time permits, I will also talk about agent-based models of mate choice, Monte Carlo models of estrous and menstrual synchrony, and how models can be used to reveal serious faults in well-entrenched conceptual and methodological scaffolds such as the concept of pseudoreplication in ecology.

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Scaffolding in Economics, Management, and the Design of Technologies

The editors have brought us together to explore whether it is possible to develop an effective vocabulary that will help unify the study of social evolution across all scales of time, space, and group size. In the introductory chapter to this volume, Caporael, Griesemer, and Wimsatt offer three conceptual tools as potential building blocks for such an integrative, cross-disciplinary approach: the reproducer perspective, generative entrenchment, and the core-configurations model. The goal of my chapter is to review related tools and vocabularies that have been developed to describe the emergence and change of structures in three fields that I am familiar with: Economics, Management, and Design of Technologies. I will focus my discussion on a concrete empirical setting, namely how firms, industries, and technologies change over time. This should allow the authors of the other chapters to see whether the tools and vocabularies deployed in my empirical setting can or cannot be ported successfully to other settings. Collectively, the assembled group of scholars might then be able to develop a clearer understanding of whether it will be possible to work out a small vocabulary that can do deep analytic and explanatory work across many disciplines or whether it is necessary to have a large vocabulary to cover all aspects of social evolution.

In reading the draft paper by the editors, I noticed that the large literature on evolutionary economics (Nelson and Winter 1982; Nelson 1995; Dosi 2000; Mokyr 2002; Murmann 2003) and the recent debate about the usefulness of Universal Darwinism in economics are missing from it (Nelson 2007; Hodgson 2009). In my view, economics is the one field in the social sciences where a compelling theory of social evolution has been worked out. This is in large measure so because economics has a well-defined selection criterion, namely, profits. This is why I present this body of theorizing and supportive empirical evidence in considerable detail.

Although some key works do appear in the second bibliography, the literature on the architecture of complexity (Alexander 1964; Simon 1981; Murmann and Frenken 2006) and the development of technology (Vincenti 1990; Baldwin and Clark 2000; Ziman 2000) is missing as well from the body of the editors' paper. For this reason I also want to bring this to our cross-disciplinary forum. My chapter is structured around the three foundational ideas proposed by the editors. I will examine how evolutionary economists, management scholars, and students of the design and evolution of technologies have thought about the issues touched upon by reproducer perspective, generative entrenchment, and the core-configurations model.

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Of Groups and Goals

For this paper I have two agendas. The first is to distinguish and characterize four core configurations in face-to-face groups, and the second is to segue from our group configurations to a discussion of its goals. Group size has attracted attention off and on from observers across a spectrum of disciplines. Although a similar range of group sizes are noted, and some consequences are posited, it is fair to say that group size fails to have much theoretical traction. I could not agree more. However, if we focus on the activities connected to reproduction and survival to reproductive age, group size per se is not critical: rather, it is byproduct of the conjunction of tasks and bodies, which of course are intimately related for all creatures. I argue that core configurations, subgroups of face-to-face groups, are repeatedly assembled—in the habits of daily life, in development and presumably in the evolutionary-cultural history of our species. For example, a dyad is a core configuration with a group size of two and modal tasks include interaction with an infant. Core configurations scaffold the evolution of certain capacities, such as finely tuned microcoordination that develops in infant-caregiver engagements as well as human-artifact interactions. The basic hypothesis is that core confi-

gurations are “the mind’s natural environment.” Unique aspects of human mental systems would have evolved in groups, should have corresponded to features of modal tasks characteristic of configurations, which in turn are grounded in the morphology and ecology of evolving humans. The theoretical traction that can come from core configurations is based on the constraints that they imply; the specific grounding of configurations is in the body and its evolutionary/cultural history in groups. So, for example, core configurations imply that the granularity of human cognitive processes is such that they can be extended to novel environments. We would also expect core configurations to vary in their level of entrenchment.

The second agenda is to reflect on the workshop, as an illustration of reproduction, core configurations and generative entrenchment, in its own process of scaffolding and articulating ideas, papers, disciplines, configurations, and relationships. (This may be a stretch and an opportunity to reflect on the scaffolding of humor.) The reflection will be a collaborative effort, built over the days of our workshop activity, and shifting into the discussion of our major goal: The Book.