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The Material Basis of Evolutionary Theory

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When I came to the Wissenschaftskolleg, I had a clear conception of my project. I would write a book "scaling up" the ideas and argument of a recent long paper analyzing the units of selection controversy in evolutionary theory. That paper put the whole controversy in philosophical focus by describing two strategies for making evolutionary theory more general. These strategies both abstract from organisms and their genes to produce a framework for a hierarchical theory operating at the multiple levels of molecules, cells, organisms, and groups. But they do it in different ways that make different demands on the rest of biological theory as background to evolutionary theory. The book would therefore be about abstraction as an epistemological strategy of representation. It would use information from my studies on visual representations of Weismannism – the biological theory used as a background resource in abstractions of evolutionary theory — to pursue an alternative, unified conceptual framework for evolution and development, one that got the causal logic of evolution right for all levels of organization. I thought that the book would close out the phase of my research concerned with units of selection and formulate some broad philosophical concepts that would take me to a new phase.

This straightforward project and comfortable year in Berlin were not to be. I quickly discovered that the old phase of my research had already

ended with the long paper and refused to be scaled up into the book I planned. 1 had already moved on without knowing it. My recognition of the shift was made clear by fortunate interactions with two informal groups within the Kolleg: the "visuality group" and the theoretical biology group. Discussions about diagrams with Svetlana Alpers, Michael Baxandall, and Michael Camille sharpened my thinking about visual representation and also opened new avenues of attention to the visual. Their ideas and suggestions led me to a new philosophical perspective that I am now incorporating into a very different book.

Peter Hammerstein and Eörs Szathmâry pushed my understanding of evolutionary biology in new directions that will also be incorporated: a new analysis of the genotype/phenotype relation and a deeper appreciation of origin of life/genetic code arguments in generalizing evolutionary theory. Eörs opened my eyes to many ideas in theoretical biology that I knew were important but which I did not fully understand. The introduction he gave me to the strong tradition of theoretical biology in Hungary promises to strengthen not only my project, but also the ties between us and our two universities. I also want to register the grace notes added to my understanding of history through reading works of my colleague Shahid Amin. In addition to a better ear for the language of history, Shahid taught me that the perspective of subaltern studies works well for understanding the social status hierarchy of the sciences and of science studies. Continuing conversations with these and many other new friends that began in chaotic, chance meetings at the beginning of the year have contributed to the generous intellectual life the Kolleg fosters. Berlin is indeed a cross-roads between east and west for trade in ideas and it will take a long time to sort the treasures I picked up from nearly every encounter, nearly every Tuesday colloquium.

My interest in the units of selection — the problem of defining the things on which the process of natural selection can operate — changed fundamentally when I began to consider the role played by August Weismann's theory of the continuity of the germ-plasm and discontinuity of the soma. Weismannism is fundamental to modern understanding of evolution through its implications for the structure of the causal relations between parent and offspring and between an organism's genetic material and its phenotype. It is the theory of development used to formulate modern evolutionary theory. But by tracing diagrammatic representations of Weismannism I came to see how different the 20th century conception of that doctrine was from Weismann's original formulation in the last decade of the 19th century: Weismannism is a theory of development that only a population geneticist could love. Diagrams held the key to the reconstruction of a historical shift of thinking that I am still trying to assemble. My

work at the Kolleg this year was largely devoted to articulating the causal logic of Weismannism and tracing its consequences through a variety of topics and levels of current biological investigation. Work at the Kolleg has made it clear that my philosophical mistrust of the language with which genome/phenotype relations are described is well-founded and that my turn to diagrams is corrective, but the point was only really brought home to me last week while lunching with Camille and reading Baxandall. Lunch, reading, and conversation: such are the ways and means of the Kolleg.

Initially, my concern with Weismannism was accidental. It was merely the substrate upon which I and my Chicago colleague, William Wimsatt, were exploring a philosophy of diagrammatic representation that might be useful for tracking scientific change. There is a tremendous diversity of diagrammatic forms and techniques included among representations of Weismannism and we wanted to understand these generally. But we did not yet have a rich enough armamentarium to do much with our materials. While our materials accumulated, my attention shifted to the use of the diagrams as a way to reconstruct the causal logic that serves as a background for current theories in the philosophy of the units of selection. But I was also anxious to understand diagrams of all kinds and the visuality group stimulated me to study the history of techniques for producing scientific diagrams, explore methods for analyzing them, and work toward a philosophy of representation for what I call "technologies of description" (influenced by Jack Goody's concept of "technologies of the intellect").

The main argument of the book that is now emerging is that to generalize evolutionary theory, a proper understanding of the relation between evolution and development is needed. This understanding is hindered by the transformation of Weismannism from a doctrine about the material process of hereditary continuity through development to a dogma about the flow of genetic information. My critique of the informational turn is based on an image of the relation between evolutionary science in the 19th and 20th centuries: biologists had the right problems in the 19th century and understood how they fitted together, but not the right technologies for formulating good theories to solve them; in the 20th century we got adequate technologies but lost sight of important perspectives on the significant problems.

In order to correct this trend, I worked toward a general description of reproduction as the basis for interpreting evolutionary theory as a theory of the flow of biological matter, rather than its idealization — flow of genetic information. This approach offers a counterpoint to the currently popular but poorly analyzed concept of replication. This far my current

thinking is in accord with the old conception of the project. But now I want to embed this description in a philosophical analysis of formal concepts of relation, capacity, and process and apply it to distinguish between heredity, heritability, and inheritance. These three concepts are critical to understanding hierarchical models of evolution. The visuality group has emboldened me to explore the logic of these relations in terms of what is, and can be, visually represented in diagrams and to reformulate my earlier critique of the generalization strategies in visual terms.

The critique points up the inadequacy of 2-place relations like genotype/phenotype for such theoretical work. The result is a new conception of that relation and also for the relation between the sciences that rely on it. Genetics is interpreted as a certain kind of special-case developmental biology, the biology of "developmental invariants", and development — through its analysis of gene transmission. Consideration of developmental invariance and symmetries, I argue, leads to a more powerful perspective than that of "laws" of genetics in evolutionary theory.

But consideration of the role of background theories in the relevant 3-place relations is enough to raise serious problems for generalizing evolutionary theory. Lineages — the entities that evolve — are complex, hierarchical, historical structures. This fact led me to an examination of the historical character of evolutionary science and the hierarchical, historical structure of organisms, populations and species. I hope to use the ideas I have been working on all year to shed light on the conceptual problems of formulating hierarchical models of evolution.

In addition to changes in the content of my project, I also evolved a new method of working that has proved quite fruitful: I succeeded in breaking away from the computer and developed the habit of writing down my notes and ideas in yellow notebooks. This banal change of habit allowed me to recover an important visual aspect of my own work, for while it is easy to type and compose words on a computer, it is not so easy (for me) to compose and think diagrammatically with a computer. The notebooks have become an indispensable tool, first in the discovery that my old project was finished, and then in the process of constructing a new one out of the old.

The Kolleg's method of "remote access" to libraries, dubious to my mind when I first arrived, has also played an important role. I learned for the first time what a truly effective library staff can do and also what the difference is between intellectual exploration and self-distraction by browsing. While the library staff kept me isolated from my usual distractions, the computer staff kept me connected to colleagues around the world with whom frequent conversation is essential. My German teacher, Eva Hund, tried valiantly to expand my range of conversational possibilit-

ies. (And, while my ability to read scientific German is still limited, I am more proud of the fact that I can make jokes with Herr Riedel and conversation with Frau Sanders and Frau Sonnenberg.) In the long run, the chance to reflect on and change my intellectual methods and habits will probably prove more valuable than any of the products that resulted from this year's work.

The old project is now fossilized in the paper 1 revised over long months at the Kolleg. "The Informational Gene and the Substantial Body: On the Generalization of Evolutionary Theory by Abstraction" will soon be published in a book edited by Nancy Cartwright. I have spent the last few months reformulating my thoughts in notebooks and files that are being worked up into a new version of a book, as well as in lectures before the Berlin *Forschungsschwerpunkt Wissenschaftsgeschichte und -theorie* (directed by Lorenz Krüger) and a workshop on systematics as a historical science at the *Museo Civico di Storia Naturale di Milano* (organized by Michael Ghiselin)_ (I want to express my thanks also to Leo Buss, who invited me to the Kolleg in the first place.)

I am also happy to report that my family thrived in Berlin. My three year old daughter Ellen found new friends and learned to sing in German at a bilingual *Vorschule.* My one-year old daughter Kate has now lived more of her life in Germany than in the US, learned to walk and began to talk here, and even says "ich bin" to refer to one of our favorite *Kinderbücher.* Their help with my project was all and none. Although raising children is the hardest job anywhere, my wife Connie shouldered most of that burden with humor in a foreign country and without our usual support system. I want to thank her as well as the Wissenschaftskolleg for making a fruitful year possible.