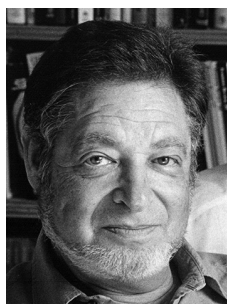


## On the Crisis of the Concept of Gene, and Levels of Organization of Matter

Extracts from the interview between *INTERdisciplina* and Steven Rose,\* who approaches various aspects of discussions among theorists on biology, in the light of new discoveries.



*In your opinion, what are the limitations of the classical concept of gene, in the light of recent knowledge concerning genotype-environment (or environment-genotype) interactions? What are the consequences of the crisis this concept is going through, or of its reformulation in a new outlook on nature that recognizes the existence of multiple levels of causality?*

The 'classical' concept of the gene—by which I mean the simplified way in which it had been presented in teaching texts and texts of advocacy like *The Selfish Gene* (Richard Dawkins, Oxford University Press, 1976), was in trouble long before the sequencing of the human genome—. You could argue that it was in trouble ever since the attempts to replicate Mendel's sweet pea studies with other species back around 1900.

There's always been a discrepancy between the way population geneticists/evolutionary biologists modelled genes as heritable units and the molecular biologists' understanding of what constituted a gene. For the former, genes are theoretical entities to be plugged into equations—eg Dawkins' example of 'a gene for bad teeth.' For the latter, genes are engaged in day to day molecular interactions especially during development: the Beadle-Tatum one gene = one enzyme, or one gene = one protein simplifying concept of the 1930s was a fine heuristic model at the time, but was of course unsustainable as genetic knowledge increased).

This discrepancy has been exacerbated by—was part of the—split between genetics and developmental biology, which began in the early part of the last century and continued almost until the present day. But now we see how Evelyn Fox Keller's<sup>1</sup> (*The Century of the Gene*, Harvard University Press, 2000) became,

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by the millennium, ‘the disappearing gene.’ The idea of 22 thousand genes in the human genome for 100 thousand proteins and however many trillion cells means that the DNA sequences that comprise ‘real’ genes are massively alternatively spliced, edited, recombined, fragmented and reinterpreted by cellular processes amongst which the current interest in epigenetics—the ‘marking’ of genes during development and consequent on experience—is just one, though an important part.

I say experience rather than environment because this emphasises the active role of the organism in choosing, manipulating and changing its environment as opposed to being merely a passive subject ground between the upper and lower millstones of genes and environment. (Dawkins ‘replicators’ and ‘vehicles’). Remember too that ‘environment’ is a portmanteau word that embraces everything from the cell cytoplasm to the ecosystem, and also of course, especially for humans, the sociocultural and familial environments in which we are immersed from childhood on. On ‘the environment’, too, recall the points I make in *Lifelines: Life Beyond the Gene* (Penguin Press, 1998; Oxford University Press, 2003)—that were established by Richard Lewontin<sup>2</sup> before me, about how the environment is defined by the organism—that is, which features (gravity, surface tension etc) are relevant.

So, to answer your question, for me the most important consequence of the crisis is that it has once more placed the organism rather than the gene at the centre of life. Even this will not be enough, for just as the gene is embedded/embodied in the organism, so each individual organism is embedded in a population and an ecosystem, and indeed in a temporal flow that tracks back not merely through its own past individual history but through the evolutionary web.

The issue of ‘levels’ is more problematic. Hilary Rose<sup>3</sup> rejects the concept as it implies hierarchy with the ‘lowest’ level being the most fundamental; she would prefer the concept of different discourses. On this she and I have one of our rare theoretical disagreements. I see no problem about recognising different levels of organisation of matter, from atoms to molecules to cells to organisms to ecosystems at each of which increasing levels of complexity, different and

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2 A leader in the development of the mathematical bases of population genetics and the theory of evolution, and a pioneer in applying molecular biology techniques like gel electrophoresis in matters of genetic variability and evolution.

3 English sociologist, has published numerous works on sociology of science from a feminist point of view. With Steven Rose, she delivered a series of lectures on “Genetics and Society”, at Gresham College in London. One of the tangible results of this collaboration was the edition of *Alas Poor Darwin: Arguments Against Evolutionary Psychology* (published by Vintage in 2001).

irreducible organising principles appear. So, for instance—to return to a debate I once had with Max Perutz, biochemistry which involves metabolism of molecules constrained in particular spatio-temporal patterns cannot be reduced to chemistry. However, I agree with her (Hilary) that the issue of levels is confounded with that of disciplines/discourses and their separate histories, eg biochemistry/physiology.

This gives rise to questions over the epistemological/ontological status of levels. For Marxists and thinkers in the Marxist tradition—I have in mind Joseph Needham (1900-1995; english biochemist and historian of science and technology in China) here in particular—levels were clearly ontological. What I would want to insist on is the ontological unity of a material world, within which there can be and I now think (*au contraire* to my earlier views and indeed to Wilson's advocacy of consilience, which means subservience of the social to the biological) must be, epistemological diversity. To quote the English (and certainly non-Marxist) philosopher Mary Midgley (*Beast And Man: The Roots of Human Nature*, Routledge 1978) we live in one world, but a big one.

An important caveat here is that not all discourses can be redefined as about levels. I used to think that 'mind' and 'brain' were coterminous, as in my early book *The Conscious Brain* (1976). I no longer think this, and reject the reductionism of my fellow neuroscientists who argue (eg Crick, Kandel) 'you are your brain.' The concepts of personhood, of self and of mind, may be dependent on a person possessing a brain, but they are also not just irreducible, but also not even discussable in biological terms. I won't expand this here as it is outside the terms of this question, but it is one of the themes of the book Hilary and I are now working on.

As to levels of causality, it seems to me one of the prime problems in science—or, better, wissenschaŕft—to locate the determining level for any given question/problem. You couldn't play football if the physical properties of ball and pitch, and human physiology, were different, but you don't need to know them to discuss the rules of the game, or why Germany won the World Cup. The causes of illegal wars are not to be found in abnormal transmitter levels in politicians brains. But the proximate causes of Alzheimer's disease are the faulty biochemical mechanisms that result in plaque formation and neurofibrillary tangles. Incidentally, I dislike the evolutionary biologists' distinction—I think the term derives from Ernst Mayr, German evolutionary biologist (1904-2005)—between 'proximate'—physiological—and 'ultimate'—evolutionary—causation. Ultimate is god-like in its magisterial certainty (Aristotle) so I would say proximate and distal.

## On Extended Synthesis

*Some authors, such as Massimo Pigliucci, speak of the need of an “extended or amplified synthesis” in evolutionary biology, while other researchers, like Eva Jablonka, speak of new dimensions that must be taken into account in a more integral explanation of evolution. In this discussion, themes such as the levels at which variation (phenotypic, genetic, environmental, epigenetic) occurs, the non-linear relation between DNA and peptides (measured by the alternative edition of RNA), the existence of additional levels of causality regarding micro-evolutionary forces, and other such themes have been very relevant. There appears to be a parallelism with your call to re-integrate biology. Do you believe that what is required is an expansion of evolutionary biology’s research program, or a conceptual revolution that involves other ways of understanding relationships between levels of material organization? How can we transcend the barriers implied by philosophical and ontological reductionism in biological explanation?*

I’ve really addressed most of these questions in my first answer. I’m not as you know an evolutionary biologist, but from where I stand, the obsession of the ultra-Darwinists with natural selection as the only mechanism of evolutionary change, and the gene as the single ‘unit of selection’, seems manifestly wrong. Not, I insist, for the reasons that Fodor (American philosopher and psycholinguist) adduces in his recent book (*What Darwin Got Wrong*, Jerry Fodor and Massimo Piattelli-Palmarini, Farrar, Straus and Giroux, New York. See the exchanges of correspondence on this in the *London Review of Books* vol. 32 nº 13, July 2010, for instance). I agree with Darwin who insisted on pluralism, that natural selection (NS) was a principal but not the only mechanism of evolutionary change. (it wasn’t NS that wiped out the dinosaurs). And it seems self evident to me, first, that NS acts on a life cycle—not simply the adult organism—and that there are multiple levels on which NS can act: gene, genome, organism, population, species and ecosystem. Also that not all evolution requires changes at the gene level—there is well established evidence for dauer phenomena, that is transgenerational transmission without gene change (eg via epigenetic marking) and Jablonka’s argument for behavioural level evolution. And there are other processes in play including of course sexual selection, drift, etc. Dover would include what he calls molecular drive, but I’ve never really understood what this entails. Waddington’s view was that such changes could ultimately be fixed—confirmed as it were—by gene changes that catch up with the phenotype. These are rich areas for current and future research. But as I’ve said, I’m a neuroscientist, and we have problems of our own to resolve.

## On Laws of Form or Historicity in Biology

*In your book Lifelines: Life Beyond the Gene, you state that a defense must be made of the historical character of the processes studied by biology. We would like you to expand on this explanation. Why should we defend history as part of biology at a time when theoretical developments from physics to complex systems can apparently explain the diversity of living forms on the planet, at least this is what some discourses maintain. In this notion of history as a key aspect of evolution, what roles do contingency and chance play? How does this enrich our integrated view of biology?*

There may be something of a confusion here. The term history—and it's probably my fault—confounds two different processes. On the one hand, I am saying that living systems exist in time as well as space—hence the need for a life cycle/lifeline perspective—their own life cycle and that of the evolutionary history that has produced it.

On the other, I am arguing that the science we practice, the tools, concepts, rules of procedure and experimental design, the metatheoretical framework we bring to our work, cannot be understood without embedding it in the history of our discipline, which is itself embedded in the cultural history of our own society; that is, for western science, an inherently reductionist global capitalism.

*On the heuristic power of a dialectical perspective, in the same book you posit the relevance of two, perhaps ontological, categories: “life trajectory” and “homeodynamics”. From our perspective, these two categories allow for a better understanding of the dialectical interaction between organism and environment as part of a process. How, in your view, does a dialectical approach contribute to the study of evolution, moving us, so to speak, towards an historical or phylogenetic field? Why does a dialectical point of view help us better understand change in an evolutionary relevant or profound temporal dimension?*

I don't want to return to Engels *Dialectics of Nature*—fascinating as a historical document that the book is—nor to the sterilities of Stalinist Diamat and the attempts by writers like Prenant—although Haldane's introduction to the English translation of Engels is more modest it is still unduly subservient to the master—to shoehorn the biology of the 1930s into such orthodoxies. Nor do I want to get involved in debates about the multiple meanings and uses of the word dialectics. I am sure that Dick Levins in his responses to your questions will be much clearer than me (see *INTERdisciplina*, p. 205). What I do think important for biologists is:

First, to be aware of the perils of reductionism and the inappropriate attribution of causation that mechanical materialism insists on and a dialectical materialism can avoid; hence, an emphasis on levels.

Second, to strive to choose the right level of biological organisation at which to study the question at issue (this is nicely illustrated by the current dispute in the European Union's billion euro Human Brain Project where there is a bitter fight between those who want to model the brain in silicon from the bottom up—ie at the molecular level—and those who want to start at the top with cognition).

Third, to focus on the dynamic properties of living systems rather than their static appearance at any moment; hence, homeodynamics and lifelines; stasis is death.

Fourth, to move away from an emphasis on objects—things—and towards process, the continuous changes that go with the paradox that all living organisms are at the same time *being* one thing and becoming another; hence, autopoiesis.

Fifth, to recognise the historicity of our research in the double sense I described above.

Sixth, to recognise that every experiment is an abstraction from the complexity of the world. We have to reduce variables, control 'external' conditions and create an artificial world within which we can draw reasonably certain conclusions, albeit conclusions shaped by the artificiality of what we can measure, including our technology and instrumentation, and, for living systems as studied by physiologists, biochemists etc, the constraint of isolating or constricting the organism from its environment/social interactions. Most of the time, when the conclusions from our artificial world are placed back into the complexity of the real world, they often fail or mislead.

## On Sociology of Science

*Regarding the work you coordinated during the seventies, such as The Radicalization of Science or The Political Economy of Science, which had a more sociological approach to science, which elements of theses analysis are still worth preserving and which have become outdated, given the geopolitical transformations of the last four decades?*

Hilary is the sociologist of the pair of us, and it would be better to address this question to her. However, you can see some of the elements of our answer in the analysis of the life sciences within and as part of the political economy of a global, footloose, neoliberal capitalism in our recent book: *Genes, Cells and Brains: the Promethean Promises of the New Biology* (Hilary Rose and Steve Rose, Verso, 2013). Briefly, the earlier books were written at a time of optimism; since then things have only got worse.

## On Neurosciences

*In reference to your neuro-scientific work and your reflections concerning the origins of human consciousness, do you consider that the dialectical method used by Hegel and Marx (making allowances for the differences between these two authors) is still relevant in explaining the development of human consciousness and self-consciousness? With what evolutionary biological perspective do you think is it compatible?*

I don't really want to discuss Hegel and or Marx on consciousness. For one thing, I am not really qualified to do so. For another, consciousness is a word with many meanings and uses. (Freudian unconscious, class consciousness, feminist consciousness, philosophical debate about first person/third person perspectives, dualism, qualia, etcetera). So let me reply from within the materialist perspective of the life sciences in general and neuroscience in particular. I don't take the reductionist position of my early book *The Conscious Brain* (1973), nor the simplistic 'you are your brain' of many neuroscientists. I mentioned above who would define consciousness as merely awareness—of being awake and not asleep. I would want to insist that consciousness is an evolved property and as such is not epiphenomenal but has survival value for profoundly social organisms like humans. But also, that it is an emergent property, dependent upon and mediated by embodied brains, but not reducible to them. Consciousness in this sense occurs in the present and past remembered history of interactions between humans and their physical and above all social and cultural environments. This is a complicated set of thoughts that I can't yet formulate to my satisfaction... But I'm working on it. ■

