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Life – After Canguilhem

Paul Rabinow and Carlo Caduff

Keywords biology, genomics, information, knowledge.

Georges Canguilhem's history of science investigates life as both form (*le vivant*) as well as experience and knowledge of that form (*le vécu*). Hinting at James D. Watson and Francis Crick's paramount discovery of the double helical structure of the deoxyribonucleic acid molecule, Canguilhem identified in his 1966 essay 'Le concept et la vie' a shift in the understanding of life. Dropping 'the vocabulary and concepts of classical mechanics, physics and chemistry, . . . in favor of the vocabulary of linguistics and communications theory', life had acquired a new language, Canguilhem observed. Operating with terms such as code, information, instruction, message, meaning, and program, molecular biology resembled neither natural history, nor architecture, nor mechanics; it resembled grammar, semantics and syntax. The problem took a different form; life was now framed in terms of organization through information. 'If we are to understand life, its message must be decoded before it can be read', as Canguilhem put it (2000: 317). The structuration of matter and the regulation of functions was set to be explored on a different scale.

In response to the ascendancy of the biosciences, the completion of the Human Genome Project, and a series of gene mapping and DNA sequencing initiatives, commentators have time and again pointed out that a shift has occurred in the epistemology of biology. Human and non-human life, it is argued, is now envisioned at a molecular scale. Recent developments in bioscience and biotechnology have enabled the re-engineering of organisms, organs and cells by way of manipulating their molecular make-up. In contemporary biomedicine, the diagnostic and therapeutic endeavor seems increasingly anchored at the molecular level. Biology has come to 'visualize life phenomena at the submicroscopic region – between 10^{-6} and 10^{-7} cm', Nikolas Rose recently remarked. For Rose, this momentous shift of scale amounts to nothing short of a molecularization of life. 'This molecularization was not merely a matter of the framing of explanations at the molecular level. Nor was it simply a matter of the use of artefacts fabricated at the molecular level. It was a reorganization of the gaze of the life sciences, their institutions, procedures, instruments, spaces of operation and forms of capitalization', concludes Rose (2001: 13). Tantamount to the capacity of contemporary biotechnology and biomedicine to reshape life at a molecular level is the advent of a new type of biopolitics, or so it seems.

A closer look at contemporary events in post-genomic biology offers a different perspective. Today, we are not witnessing a linear progression towards a general molecularization of life, but rather, and more interestingly, inflections of a re-biologization of life. A series of gene mapping and DNA sequencing projects have revealed the genetic constitution of bacteria, yeast, worms, flies and chimps. The systematic production of genomic data performed on an industrial scale has generated a slew of information. That information, however, has not led to immediate biological understanding. The problem biologists and biomedical scientists face today is how to utilize genomic information to gain biological understanding. It has become clear by now that DNA sequence information does not reveal gene regulation. The specification of when, where, and for how long a gene is turned on or off is still missing. Additionally, it is not always possible to deduce

protein function from DNA sequence information. As Roger Brent, a molecular biologist, pointed out in 2000, 'the most important observation from genome sequence is probably that . . . the function of between 15% and 40% of the proteins encoded by any genome is not apparent from their sequence' (2000: 170). Identification of polymorphisms in coding sequences, regulatory sites, and splice junctions often yield more questions than answers. The function of non-coding regions, and the consequences of variation in non-coding regions, is unclear.

The recent discovery of non-coding RNA genes that produce functional RNA molecules rather than encoding specific proteins has revealed the limits of the information paradigm of molecular biology. Ironically, as Sean R. Eddy (2001) remarks, a considerable class of genes has remained invisible in the era of complete genome sequences. The mass production of genomic information, moreover, is prone to errors. Roger Brent more generally admonishes that 'genomic data of all types are typically lower value adding than those obtained from classical ad hoc experimental approaches; they typically do not immediately address the questions about regulation, mechanism, and decision making that are of greatest interest to contemporary biologists' (2000: 173). The problems are explicable on the ground of the configuration of the project itself. Brent argues that 'the underlying logic used to make inferences from genomic data [is] in a primitive state characteristic of an observational stage of science' (2000: 173). Perhaps, then, the definition of life as information was tantamount to that observational mode of biological inquiry.

Today, as is well known, molecular biology reassembles around functional genomics, proteomics and transcriptomics. In the emerging world of post-genomics, the generation of genomic information provides the ground for the biologization of life, making the complex interactions between cells, systems of cells, multicellular organisms, populations of organisms and their environment a focus of heightened attention. In order to understand genomic information, biology reaches out and moves beyond the limits of the molecular scale. It resituates DNA sequences and RNA regulatory mechanisms within highly differentiated cellular networks. It shifts attention from linear causal chains to non-linear dynamics. And it moves from deterministic frameworks to probabilistic explanations. Accordingly, the challenges of post-genomic biology are not only technical, organizational and financial; they are increasingly scientific. Post-genomic biology is driven not so much by efforts in decoding DNA sequences, but rather by testing hypothetical propositions in experimental settings. Electron microscopes, ultracentrifuges, electrophoresis, mass spectrometry, isotopes and scintillation counters are now increasingly utilized not for observational but for experimental purposes.

Reflecting on the implications of the revolution under way in the molecular biology of the 1950s and early 1960s, Canguilhem identified a shift in the epistemology of biology. The definition of life as organization, Canguilhem claimed in 1966, lost ground to a new conception: life as information. Today, this conception has not been totally discredited, to be sure, but its limits have nonetheless become apparent. The accumulation of genomic information has not led to immediate biological insight. The very epistemic status of genomic information is currently shifting from an end to a means of research: in post-genomic biology genome sequences are used as giant reference tools. Research, moreover, increasingly pays attention to complex interactions across multiple scales. The past decade, finally, has witnessed an intensification of the experimental bent of biological inquiry.

Reflecting on the implications of the conceptualization of life as information, Canguilhem was referring to a series of early successes in the endeavor of molecular biology. He was not referring to a particular science when he claimed that mankind makes mistakes when it chooses the wrong spot for receiving the kind of knowledge it is after. Clearly, that knowledge is only partially to be found by way of the molecularization of life. Today, biologists are experimenting with a broad range of spots so as to turn genomic information into biological knowledge. Contemporary inflections of the biologization of life are nothing but an attempt to move things around, once again, in a different manner, so as to flourish and survive. History has moved on, and history will continue to move on – and so should our inquiries. Nonetheless, Canguilhem's project remains relevant if it is taken as what it was meant to be: a reviving invitation to investigate the unexpected emergence of objects and the unpredictable reconfiguration of forms as they assemble into an ever-shifting understanding of life.

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The Determination of Life

Steven D. Brown

Keywords communication, life, vitalism

Eight Incommensurable Propositions on the Determination of 'Life'

Life is a term which enables the rupture of existing categories

When Daniel Dennett claims that evolutionary theory is akin to a 'universal acid' which is capable of corroding extant systems of thought and epistemic preoccupations, he is merely restating the central thrust of vitalism – that the thinking of 'life itself' necessarily undercuts established dualisms (e.g. nature/culture; mind/body). The cultural premium which is accorded to contemporary Darwinism and to the 'life sciences' may be seen as in direct proportion to the extent to which they are able to present themselves as having taken charge of 'life itself' as a problem. Critical interrogators of the life sciences, such as Donna Haraway, therefore confront the problem of analysing a practice which often disappears into its own gestures of boundary-blurring (a problem which she proposes to counter through poetics and reflexivity).

Life is a term which enables the preservation and 'future proofing' of existing hierarchies

The notion of a 'tree of life', typically found in high school biology textbooks, neatly retains the principal features of the medieval 'great chain of being' by substituting the ramified branching of a centrifugal movement of evolution away from the 'primeval soup' for the centripetal movement of sentience from the lesser beings towards the Prime Mover. Hierarchy is nevertheless retained, when either scheme is considered from an implicit notion of the 'perfectibility of life'. This latter notion may be innocuously presented as 'good environmental fit'. In either case, the logic is one well described in Deleuze and Guattari's characterization of 'arboreal thought'.

Life is the object of a superior mechanism

Although vitalism and mechanism are often considered as separate poles of thought, the forms of mechanism which emerge in the wake of 20th-century postwar cybernetics authorize themselves in relation to their ability to grasp 'life' as merely the most complex of a series of imagined mechanisms. In his popular writing, Norbert Wiener, for instance, displays such confidence that life is capable of being rendered as 'system' that he proposes an ethical debate on the powers which are newly accorded to 'the human' as a consequence. Of the many paradoxes that this creates, surely none is finer than the attempt to restore dignity to the human subject by atomizing its humanity into the Cantor dust of classical communication theory.

Life is reducible to communication

The rise of molecular biology is premised, as Jacques Monad and François Jacob beautifully display, on the positing of 'information' as the basic biological unit. Which is to say, by holding the term 'life' to be only a folk category which denotes the complex ontogeny of coding biological materials within an emerging functional assemblage. However, the recognition that such elementary forms of communication are interdependent with 'noise' – or, put slightly differently, that much of the genetic 'junk' actually contributes in hitherto unknown ways to embryonic development – problematizes the notion that life could be reproduced on the basis of communicative rationalization.