Building Blocks of Life: Synthetic Biology's Newness

On May 20, 2010, the J. Craig Venter Institute announced it had created the world's first self-replicating synthetic (human–made from chemical parts) genome in a bacterial cell of a different species. In response, President Obama tasked the Presidential Commission for the Study of Bioethical Issues to explore and review the developing field of synthetic biology, with an eye toward ethical boundaries and risk mitigation. They published "New Directions: The Ethics of Synthetic Biology and Emerging Technologies" in December of 2010. Aside from ethical and efficacy explorations the report takes time to explicitly discuss the newness of synthetic biology, and the Commission takes a decidedly pragmatic stance on said newness.

The promise of assembling living organisms from non-living parts to serve human needs has long fascinated imagination, and indeed solid inroads have been made into the manipulation of DNA. However, the announcement by the J. Craig Venter institute was unique in that it blurred the line between manipulation of life and outright creation of life. It was a landmark, if controversial, development in synthetic biology, which is "an emerging field of research that combines elements of biology, engineering, genetics, chemistry, and computer science." (New Directions, 36) Synthetic biology is inherently interdisciplinary; it is, "a scientific discipline that relies on chemically synthesized DNA, along with standardized and automatable processes, to address human needs by the creation of organisms with novel or enhanced characteristics or traits." (New Directions, 46) This discipline, unsurprisingly, attracts much optimism and concern; directly creating life to serve human needs sounds at once brand new and very ancient, something gods might have done. Despite any philosophical considerations, synthetic biology is a rapidly maturing endeavor.

There are two main approaches to Synthetic Biology: "bottom-up" and "top-down." The Venter Institute's work represents a key milestone in the more recent "bottom-up" approach to

synthetic biology based on creating "novel biochemical systems and organisms from scratch, using nothing but chemical reagents." (36) But was the Venter Institute's specific accomplishment new? The Commission views Venter Institute's work in an interesting light. To the idea that the Venter Institute created life the report is quick to brush the hype aside:

> "The technical feat of synthesizing a genome from its chemical parts so that it becomes self-replicating when inserted into a bacterial cell of another species, while a significant accomplishment, does not represent the creation of life from inorganic chemicals alone. It is an indisputable fact that the human-made genome was inserted into an already living cell. The genome that was synthesized was also a variant of the genome of an already existing species. The feat therefore does not constitute the creation of life, the likelihood of which still remains remote for the foreseeable future." (2)

The Venter Institute work, in the Commission's eyes, is not Earth-shatteringly new; the Institute made a leap along technical lines, but did not manage to create life. From the report's wording it appears that for Venter Institute's work (or any that of other researchers) to qualify as "creating life" there would need to have been a novel, non-naturally occurring genome sequence involved and perhaps the synthesis of many more components of the organism, maybe even macrostructures of the cell. If a group manages to synthesize a larger proportion of those systems in a future designed organism, then perhaps that group will get the prize of having "created life," and that work can be considered inherently new. Venter Institute's work, it appears, is still in a blurry area between iteration and outright newness.

So is the field of Synthetic Biology itself new? The report asks the question directly and seems intent to provide balance, if only in a brief segment of the overall paper. It states upfront, "The idea of managing or manipulating biology to identify or develop specific characteristics is not new. Scientists have used DNA to create genetically engineered cells and organisms for many years; the entire biotechnology industry has grown around our expanding abilities in this area." (2) Yet the Commission continues, stating that Venter Institute's research and synthetic biology in general are the early stages of a "new direction in a long continuum of research in

biology and genetics." (2) Synthetic biology could be described as a new direction emerging out of established fields, particularly molecular biology. (36) The field converges the techniques and knowledge of biology with the techniques and practical principles of engineering. "Whereas standard biology treats the structure and chemistry of living things as natural phenomena to be understood and explained, synthetic biology treats biochemical processes, molecules, and structures as raw materials and tools to be used in novel and potentially useful ways, often quite independent of their natural roles." (36) More than specific techniques, Synthetic Biology seems able to claim some measure of newness through its new perspective.

As the report touches on, views of newness for synthetic biology vary among scientists; some see it as revolutionary and a qualitatively new field of science, while others see it as incremental advances in decades-long growth in molecular biology, genetic engineering, and microbiology. (48) "The term synthetic biology itself was first used as early as 1974 by Waclaw Szybalski who saw molecular biology's promise evolving from description to manipulation of genetic systems, heralding a new era of synthetic biology." (48) Yet the report separates the specific implementations of synthetic biology from molecular biology along functional grounds. The report states, "One characteristic that distinguishes the synthetic biology of today from the molecular biology of years past is the significant role played by standardized parts, computers, and automation, accelerating a trend prevalent throughout biotechnology." (48) Moreover, the involvement of engineering in synthetic biology changes the nature of the study. "In contrast to conventional research in biology, the quest for predictable functions and standardization lies at the heart of synthetic biology. In this way, the field reflects the influence of engineering on its development." (49) This appears to tip the scales in favor of genuine newness.

Indeed, using Thomas Kuhn's conception of newness in terms of scientific revolutions illuminates synthetic biology, but also obscures it. Kuhn's conception features conflict of

existing and emerging paradigms driving revolution; however in synthetic biology convergence between disciplines seems more prevalent than outright conflict and displacement. The Commission does not paint a picture of a particularly fraught emergence for synthetic biology despite niggles about newness from outsiders, which is expected in Kuhn's conception; the discipline appears to have emerged relatively cleanly from molecular biology and genetic informatics. Most importantly for understanding when a revolution has occurred–even if it was invisible–under Kuhn's conception, is that after a revolution, "Scientists see new things when looking at old objects. In a sense, after a revolution, scientists are responding to a different world." (6) Thus the seat of synthetic biology's newness stems not from its techniques but from its perspective: through the lens of synthetic biology life is a toolkit.

The Commission's report does not spend a great deal of time analyzing the newness of synthetic biology before launching into applications and risks and generic policy recommendations. The report takes a diplomatic stance on expressly stating that synthetic biology is new, since this was, and still is, debated within the wider scientific community. However, the report paints synthetic biology as new enough to merit special attention.

> "The potential promise of synthetic biology is immense. Research in synthetic biology has led to the development of genetic circuits and modules with predictable behavior, creation of novel combinations of cells in the laboratory that behave synergistically, and ever-expanding DNA construction capabilities. The field, however, is young. Our understanding of complexity and variation in natural and synthetic parts and systems is far from complete, and the technical tools and skills required for large-scale synthesis and production continue to be refined. If carefully nurtured and guided, however, synthetic biology may provide an opportunity to integrate engineering and the biological sciences into the living world, with potential benefits to national and international security, food and energy supply, public health, and economic well-being." (50)

The report uses the word "new" many times to describe synthetic biology applications and is indeed titled "New Directions." In describing synthetic biology as a convergence of engineering and biology, the report makes a strong implicit case that synthetic biology is new: it

blurs the lines between biology and engineering–between life and technology–into a new practice.

Sources Cited:

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The Structure of Scientific Revolutions
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