

Synthetic Biology - What to Expect and Fear?

By Nayef Al-Rodhan



Interactions between life sciences and engineering are now providing solid ground for many futurologists to see their postulation of a “life 2.0” reality become materialized within decades. Life sciences have undergone outstanding transformations in the past five decades and the rapid advances in synthetic biology are pushing new frontiers in the chemistry of life and the manipulation of genetics.

Synthetic biology (“synbio”) is the engineering of biology and its aim is to synthesize complex biological systems to perform functions that do

not exist in nature. It includes several engineering strategies (such as genome design and construction, applied protein design, natural product synthesis etc) and its focus is on the design and construction of core components (parts of enzymes, genetic circuits etc) which can be modelled and tuned to meet specific needs or address very specific problems. This is the crucial novelty of synthetic biology, as compared to genetic engineering: rather than just tweaking the genetic blueprints of living organism, synthetic biology is set to design and build cells with new functions, as well as new biological organism or building blocks.

The “Carlson Curve” is now used to describe the phenomenal progresses with synthetic biology in a just a span of a few years. This is likened to the Moore Law from 1965 in computers which predicted that the power of computers, as measured by the number of transistors on integrated circuits, would double approximately every 18 months. The Carlson Curve applies similar premises in synthetic biology, positing that the growing efficiency of DNA synthesis will grow hyper-exponentially as costs will decrease.

Synthetic biology is an emerging field that promises to reveal the extraordinary potential of the genetic code and reinvent biological processes. As scientists continue to grasp the knowledge on DNA, genes are combined to create new variations of life. Among the possibilities laid out by the synbio revolution are creating bacteria that eat pollution in water, diagnosing diseases, producing scarce chemicals, destroying cancer cells, generating hydrogen or recycling gold from electronics. More recently,

synthetic biology has turned to fine chemicals, such as food and fragrance ingredients and a Swiss synthetic biology company has released a type of yeast that converts sugar to vanillin.

The goals of synthetic biology are certainly ambitious and virtually limitless. The interest in synthetic biology, now pursued in more and more research centres around the world (such as the US, UK or Japan), has initiated a great deal of investment and a growing focus on practical achievements.

The vast information that is continuously obtained about life processes will enable synthetic biology to be used in varied ways in medicine, agriculture, industries, bioremediation (which uses microorganisms to eliminate toxic waste from the soil or water) or energy. Some scientists have tried to use synthetic biology to create antimalarial drugs or obtain cellulosic ethanol. The latter is especially important. This would imply identifying the appropriate genes for the enzymes that could ferment the entire plant from which the ethanol is produced (and avoid wasting a large part of the plant). At the same time, cellulosic ethanol holds promises for the environment since its carbon does not contribute to global warming. Cellulosic ethanol is ranked as one of the first energy alternatives to petroleum in the US.

Synbio: from benefits to risks

The prospect of creating life and living organisms from scratch proves that biology can now be a tool for engineers to manipulate for whatever ends. In this scenario, biology is set to become a routine process at the service of many industries. The highly creative applications of synthetic biology pursued in specialized centres show that science is exciting and future-oriented, as well as, at least in principle, premised to “make life better”.

Yet, a dystopian scenario is equally imaginable. Synthetic biology presents a set of risks that raise both ethical and security questions. Work in synbio is increasingly cheap and easy to practice outside the area of trained biologists thus posing the problem of lack of ethics and safety standards. However, even the existing standards, such as those developed in the US and other countries, are now more than a decade-old. This concern adds to environmental worries about the likelihood of synthetic microorganisms escaping research facilities and proliferating out of control, threatening public health. Tests in open environments could also easily disrupt ecosystems or ultimately lead to the extinction of some species.

While some see synthetic biology as a ray of hope for many of the world`s challenges in health, energy or environment, to some its scope is overshadowed by the numerous pathogenic risks and hazardous spillovers that it can cause.

The hazards that sceptics caution against also include deliberate misuse or abuse by states, outlawed groups or terrorists who could use synthetic biology for bio-hacking. Just like with computer viruses, “lone operators” or groups could work to develop pathogens or viruses, a threat that many forecast to become more pressing in the next decade.

The dangers associated with synthetic biology are in many ways no different than those prompted by biotechnology in general or genetic engineering but synthetic biology is quantitatively different in that it offers far more possibilities to manipulate biology.

From risks to regulation

The range of normative attempts to address safety and ethical issues related to synbio work are not inexistent but they are incomplete and insufficiently implemented or operational and even less so outside of the state-level. The 1972 UN Conventions on Biological Weapons or the Chemical Weapons Conventions of 1993 lack vigorous control mechanisms and they do not bind non-state groups as well. To address the specific challenges of synbio work, a group of civil society organizations issued The Principles for the Oversight of Synthetic Biology in 2012, which advocate for accountability, environmental justice, protection of public health, democratic participation or the application of the Precautionary Principle.

The translation of such guidelines into actual regulatory frameworks is however, yet to be achieved. The question of dual-use research remains a puzzling issue on the agenda of many private, national and international entities. If the pace of development in other fields is any indicator, we know that in

just a decade from now synthetic biology will have already grown tremendously and become more sophisticated. Creating new life forms is now a prospect in sight and this bids for new philosophical paradigms to view life, as well as consistent, pro-active steps to mitigate risks.

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