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Synthetic biology: The new era

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ABSTRACT

Synthetic biology is an emerging discipline of science, at the intersection of biology, engineering, and chemistry that involve redesigning organisms to have new phenotypes and customized abilities. While synthetic biology seems to have originated from genetic engineering, over the years, it has matured as well as diverged from it. It involves not just the transfer of genes from one or cell to another creating some variants, it also involves the assembly of an altogether novel organism or cell created part by part by the assembly of individual components of the desired function in a logical fashion. In this mini review, we will explore this new discipline and its possible applications and future promises to serve the humanity.

Key words: Biomedical research; Biotechnology; DNA sequencing; Synthetic biology

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INTRODUCTION

Advances in synthetic biology have expanded the biologist horizon to explore the possibilities to engineer and manipulate organisms thereby allowing creating bacteria stains that are genetically altered to have specific therapeutic and biotechnological benefits.[1] These, in turn, have tremendous potential with a new therapeutic power and precision.[2]

APPROACHES OF SYNTHETIC BIOLOGY

The ability to design and construct new biological parts and the redesigning of biological system for useful purposes.[3] Extraction and reassembly of biological parts along with the principles of abstraction, modularity, and standardization.

a. Two different approaches
b. Top down – to impart new functions to living cells
c. Bottom up – to creating new biological system *in vitro* by bringing together "non-living" biomolecular components.

SYNTHETIC BIOLOGY IN HEALTHCARE

Synthetic biology has a tremendous role in biomedicine and healthcare, with patients benefiting from cancer immunotherapy and chimeric antigen receptor therapy for refractory cancers.[4,5] Lentiviral vectors were used in gene therapy. In lentivirus based gene therapy, genes maybe be inserted or modified, using lentivirus in an effort to correct the defective gene.

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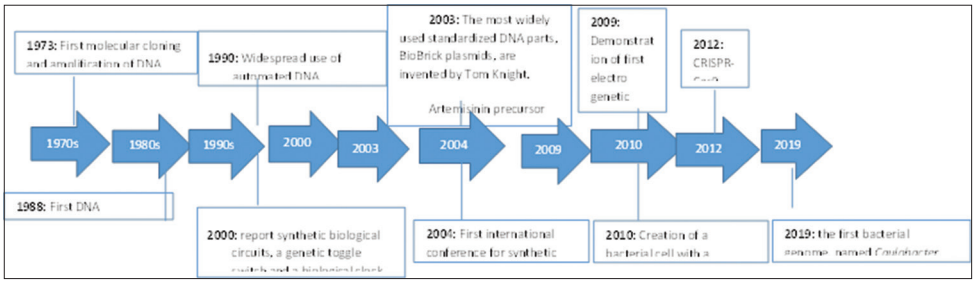

Figure 1: Time line of the development of synthetic biology

Example in Severe Combined Immune Deficiency,[6] iPS cells derived from the somatic cells of the patients which may be used to generate new tissues, or 3D printed to create organs in an effort to repair the diseased tissue.[7]

BASICS OF SYNTHETIC BIOLOGY: HISTORY

Although the concepts of synthetic biology were prevailing since 1960, a systematic framework was only established in the late 90s. This was developed with simultaneous development of biotechnology and molecular cloning techniques (Figure 1).

A big leap in this developmental pipeline came with the rapid progress in genome sequencing technologies, NGS platform, and computational algorithm so that gene manipulation become more feasible (Figure 2).[8]

The elements of synthetic biology involves the concept of continued learning, its application, feedback, and updating the protocols. It involves experimentation, using tools of genetic engineering, molecular biology, and synthetic chemistry.[9] It also involves engineering the DNA with new genetic functional elements and modules to address the biological need.[10]

MOLECULAR BIOLOGY TOOLKIT

1. Reading the DNA code – DNA sequencing
2. Copying existing DNA sequences – cloning
3. Inserting specific DNA sequences into existing DNA strands – genetic integration.

Although these methods have been implemented for many years and have been used to great effect in research, but they are not sufficient for synthetic biology.

DIFFERENCE BETWEEN SYNTHETIC BIOLOGY AND GENETIC ENGINEERING

The difference between synthetic biology and genetic engineering is shown in Table 1.

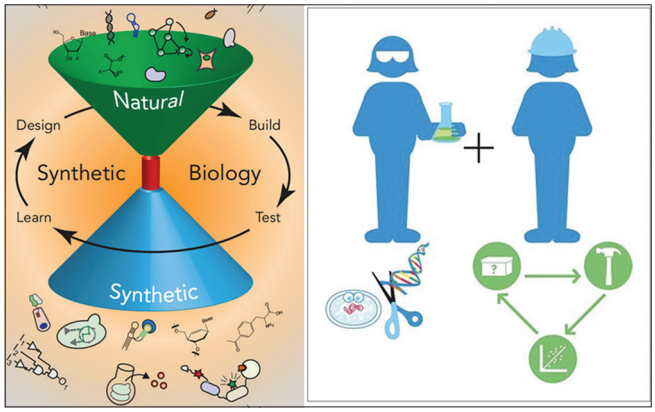

Figure 2: The basic architecture of synthetic biology blending the principles of biology, chemistry, and engineering. The rapid development of DNA sequencing technologies has helped to rapidly advance this field. Source: Ausländer and Fussenegger 2016[11]

Table 1: The fundamental difference between synthetic biology and Genetic Engineering and biotechnology. Although we have commonalities, still there are distinct domains between these two discipline

Synthetic biology	Genetic engineering
Creation of fully operational biological synthetic system from the smallest constituents	The artificial manipulation of DNA or other nucleic acid molecules to modify an organism
Relies intensively on the standardized concept of engineering involving the design of genetic circuit with biological parts from many different species	Relies on the alteration of genetic material based on a set of methodologies and is often represented as a hit and miss activity

Example of synthetic biology approach to detect environmental pollutants like Arsenic (Figure 3).

SYNTHETIC BIOLOGY-BASED MEDICAL APPLICATION[13,14]

- Engineered bacteria and microbial for disease diagnosis and treatment
- Synthetic biosensor for detecting disease
- Cellular immunotherapy
- Blood glucose control devices.

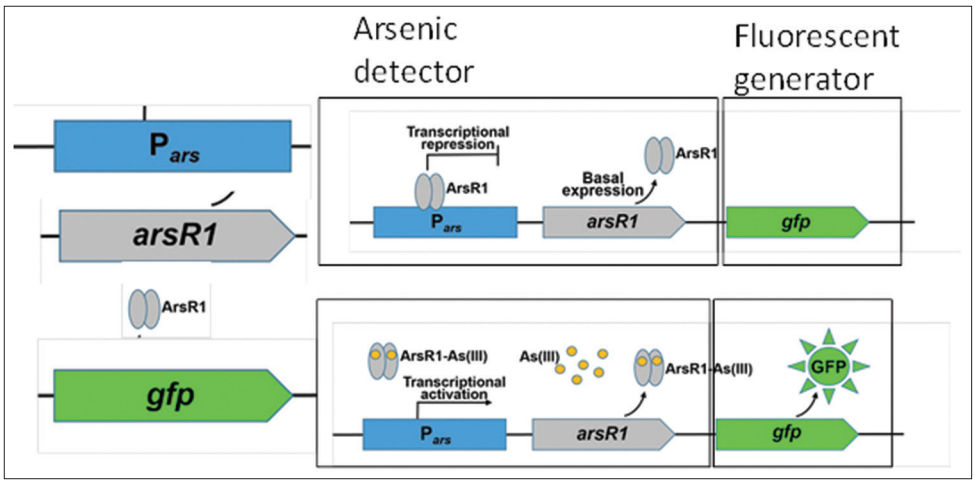

Figure 3: An arsenic detection module using the bacterial derived arsenic sensors attached with green fluorescent protein for rapid detection and surveillance. Source: Edmundson and Horsfall 2015[12]

CONCLUSION

With the advancement in biomedical sciences, along with an increased demand to develop bench to bedside applications that can address the diverse problems facing mankind, synthetic biology has been very useful and realistic in this direction. Using engineered vectors, designer plasmids, and modified chemical pathways, synthetic biology is proving to be very helpful to solve real life problems that were very challenging few years back. A thrust in this area will form the foundation of future of biomedical research empowering the society with solutions from healthcare, agriculture, genetic engineering, and bio-pharmaceuticals.

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SG- Drafted the manuscript with assistance from **SK, RD, AK, and JT; AK-** Provided critical comments and suggestions; **AK-** Assisted in statistical and data curation; **SG, SK, RD-** Conceptualized and overseen the entire study.

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