Agri Articles
(e-Magazine for Agricultural Articles)
Volume: 05, Issue: 01 (JAN-FEB, 2025)
Available online at http://www.agriarticles.com
©Agri Articles, ISSN: 2582-9882

Synthetic Biology and Its Applications

(*Rajesh S[1], Meenakshi Sundaram P[2] and Jayakanthan M[1])
[1]Centre for Plant Molecular Biology and Biotechnology, Tamil Nadu Agricultural University, Coimbatore-641003, Tamil Nadu, India
[2]TNAU- Agricultural College and Research Institute, Madurai-625104, India
*Corresponding Author's email: rajesh.s@tnau.ac.in

Synthetic biology is a newer approach of biology that combines science and engineering and referred to as Synbio, Synthetic genomics and Construction biology. Synthetic biology encompasses different approaches and often construed as the design and construction of new biological functions and systems that are not observed in nature. The term was used by **Barbara Hobom** to describe genetically engineered microbe using rDNA technology. Since manipulated with human intervention, synthetic biology is also synonymous to **Bioengineering.** Later in 2000, ´synthetic biology' term was re-introduced by **Eric T. Kool** and others at American Chemical Society (ACS) annual meeting held at San Francisco. Synthetic biology describes synthesis of unnatural organic molecules that function in living system.

Craig Venter's team created revolution in synthetic biology after successful synthesis of the complete genome of the *Mycoplasmia genitalium* bacterium which is an major step towards achieving what is to be later referred as "synthetic biology". With advances in genetic engineering, its now possible to construct full length DNA sequences which helps in transforming routinely used lab chemicals into a newer living organism. Integrating Systems and Synthetic Biology with Metabolic Engineering offers greater scope for production of novel products (Choi et al., 2019).

Scope of synthetic biology

Synthetic biology has broader scope, however in that it attempts to recreate in unnatural chemical systems the emergent properties of living systems, including inheritance, genetics and evolution synthetic biologists seek to assemble components that are not natural to generate chemical systems that support Darwinian evolution. The motivation is similar in biomimetic chemistry, where synthetic enzyme models are important for understanding natural enzymes.

Synthetic Biology tools and strategies for System metabolic engineering

Categories	Tools and strategies
DNA assembly	BioBrick assembly, Golden Gate assembly, Single strand assembly(SSA),Ligase cycling reaction (LCR),Uracil specific excision reagent (USER) cloning, Transformation associated recombination (TAR) cloning
Chromosome engineering	Site specific integration, Recombineering, MAGE, CRISPR/Cas .
Trans-acting gene expression modulation	Synthetic small regulatory RNA, Small transcription activating RNA (STAR),CRISPRi, CRISPRa, CRISP/Cas –based DNA methylation editing
Stable gene	Plasmid addiction system, stable and tunable plasmid (STAPL) system

expression	
Substrate channeling	Direct fusion enzymes, synthetic protein scaffold, synthetic DNA scaffold,, Bacterial micro compartment (BMC)
Biosensors	Enzyme –coupled biosensor, Transcription factor- based biosensor
Synthetic genetic circuits	Cello, CHOMP, Dead man and Pass code

Applications of Synthetic Biology

Synthetic biology has greater applications and ranges widely across scientific and engineering disciplines from Agriculture, medicine to energy generation. Ultimate goal is to develop commercial application that is benefits for the society.

Environmental Application

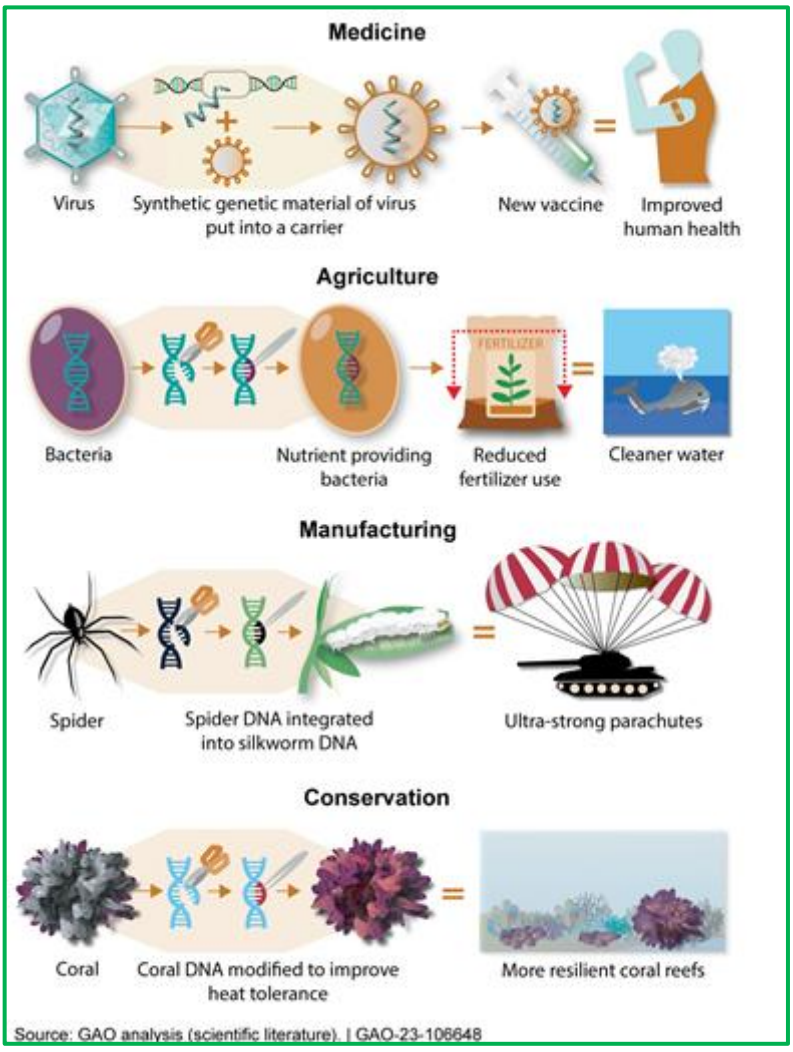
- ✓ Bioremediation – Another area with potential environmental benefits is bioremediation. Microorganism or even engineered to degrade pesticides and remove pollutants

Medicinal Application

- *In vivo* applications: There is range of potential applications of synthetic biology which could monitor and respond to condition s in the human body.Regulatory circuits could be designed which trigger insulin production in Diabetes
- Bacteria or viruses could be programmed to identify malignant cancer cells and deliver therapeutic agents
- Viruses have also been engineered to interact with HIV-infected cells, which could prevent the development of AIDS
- Engineered yeast it produce Artemisinic acid it act as Anti-malarial drug (Ro *et al.*, 2006)
- Synthetic vaccine could be produced in response to viruses that themselves evolve rapidly, such as those that cause Severe Acute Respiratory Syndrome (SARS) and hepatitis.

Agricultural applications

- Synthetic biology can modify metabolic pathways of crop plants and its genetic information and involves microbial role in agriculture.
- Huge prospects in crop breeding to improve genetic ability of crops, yield increase and ensures safety of the agricultural production environment



Applications of Synthetic Biology in various spheres of biology

Industrial Applications

- Engineered cyanobacteria and algae to produce Biofuels
- Synthetically engineered yeast it produce Farnesene used a wide range of chemical products like cosmetics, perfumes, detergents, transportation fuels such as diesel and jet fuel (Liu et al., 2022)

Limitations of synthetic biology

Potential applications of synthetic biology are not without a possible risk. Key factors that make risk governance of synthetic biology problematic are

- Synthetic biology involves the production of living organism, which by definition are Self-propagating
- Growth of internet and reutilization of many biotechnological procedures, the tools for doing synthetic biology are readily accessible.

Conclusion

With regards to ethical concern, synthetic biology requires transparency in its approach and society has to rethink through the eyes of best ethical concerns and best practices of biological data protection to give consent to read or write from someone's brain. Regulatory frameworks have to be strengthened to address judicious use and future applications of synthetic biology. Synthetic biology demands multiple skill sets and needs role of data scientists, biologists, ethical and industrial experts and technologists for safe use of the technology for human benefits and environment.

References

1. Choi, K.R., Jang, W.D., Yang, D.S., Cho. J.S., Dahyeon, P.D., and Sang, Y. L.(2019). Systems Metabolic Engineering Strategies: Integrating Systems and Synthetic Biology with Metabolic Engineering. *Trends in Biotechnology*.pp:121.
2. Liu Y, Zhang J, Li Q, Wang Z, Cui Z, Su T, Lu X, Qi Q, Hou J. (2022). Engineering Yarrowialipolytica for the sustainable production of β-farnesene from waste oil feedstock. Biotechnology for Biofuels and Bioproducts. 15(1):101.
3. Ro, D.K., Paradise, E.M., Ouellet, M., Fisher, K.J., Newman, K.L., Ndungu, J.M., Ho, K.A., Eachus, R.A., Ham, T.S., Kirby, J. and Chang, M.C. 2006. Production of the antimalarial drug precursor artemisinic acid in engineered yeast. *Nature*, 440 (7086): 940-943