Sarkar, J Biochem Eng Bioprocess 2023, 6:1

Journal of Biochemical Engineering & Bioprocess Technology

Short Communication

A SCITECHNOL JOURNAL

Could Synthetic Biology Offer Better Regulation and Control in Genetically-Modified Organisms?

Arindam Sarkar*

Department of Biotechnology, University of Mysore, Karnataka, India

***Corresponding author:** Arindam Sarkar, Department of Biotechnology, University of Mysore, Karnataka, India, Tel: 8073040330; E-mail: partho.arindam@gmail.com

Received date: 20 July, 2020, Manuscript No. JBEBT-20-15855;

Editor assigned date: 24 July, 2020, PreQC No. JBEBT-20-15855 (PQ);

Reviewed date: 07 August, 2020, QC No. JBEBT-20-15855;

Revised date: 31 January, 2023, Manuscript No. JCEIT-23-13505 (R);

Published date: 28 February, 2023, DOI: 10.4172/jbebt.100064

Abstract

Synthetic biology is a tool which allows one to study the elaborate design of biological systems. It allows one to reconstruct or redesign the genome of an organism for a specific purpose. It helps engineer new organisms or systems, which do not exist in nature to generate useful products from inexpensive and renewable resources.

Keywords: Synthetic biology; Biological systems; Renewable resources

Description

In the early years, genetic manipulations were carried out with two targets in mind – the chromosomal genome and the extrachromosomal plasmid. Traditionally, plasmids with better transferable properties have been the popular choice. The gene could be manipulated easily by using restriction enzymes [1]. The genes were mixed and matched in order to get the desired trait and once a successful manipulation was obtained, it could easily be inserted into a host through various methods of transfer such as electroporation, transformation etc. With time, genetic engineers have been able to exploit plasmids to construct genetic elements and insert them into organisms to get novel characteristics [2]. Due to different copy numbers, different plasmids could be maintained independent of one another, inside the host cells. Roughly, the more copies of a gene are present, the more the gene is expressed in the cell. However, one notable disadvantage of using plasmids is, the lack of control. The number of plasmids in a cell can drastically change over time in response to various environmental changes. The burden of carrying, copying, and maintaining extra genetic information also pose certain limitations for the host. Another disadvantage of using plasmids is that, they often become transient or get lost in a growing cell line over time. Thus, a need for a better control strategy grew in genetic engineering. Synthetic biology, came into light few years ago in order to meet this specific need. My primary interest is to use synthetic biology as a tool to create protocells or artificial cells, which would provide efficient monitoring and more control over genetic manipulations [3].

If one potential goal of synthetic biology is to engineer the regulated expression of a target gene, what amount of control versus noise is inherent in a typical biological system? How precise are the typical control mechanisms? One of the most common control mechanisms is for a specific gene or pathway to be regulated by the absence or presence of an external chemical trigger [4]. This is usually done by the use of small diffusible inducers such as IPTG (Isopropyl-D-1-Thiogalactopyranoside) or ATc (Anhydrotetracycline). In such systems, the gene of interest needs to be present behind the region of DNA which is regulated by these molecules. The IPTG or ATc molecules act as inducers and bind to the lac repressor protein. This binding frees the operator and allow the gene to be transcribed and translated. However, it is not always possible for the researcher to obtain a manipulation wherein the gene of interest is present at a region in DNA, where lac expression could be used. This poses a huge limitation to the researcher and does not allow the researcher to perform more efficient genetic manipulations due to the limited control and regulatory mechanism.

As is evident from the literature, this challenge could be overcome in synthetic biology by the use of genetic circuits which offer better regulation. What's more interesting is bottom up synthetic biology, which is best defined as creating high order complex systems using simple and natural components, starting from scratch. In my knowledge, constructing a biological system follows a particular order which is similar to constructing an electrical system. This order starts at DNA codes, which are used to form sensory elements, which are further constructed to form genetic circuits. These genetic circuits are then assembled to form modules. These modules are connected to form networks. When sufficient number of networks are formed between modules, it could be called a biological system. Programming cells and assigning them newer functions is the core objective of synthetic biology. It is evident that biological cells could be used for computing Boolean functions by constructing logic gates, as well as for storing DNA-encoded memory by using recombinases or invertases [5,6].

For example, if I were to create an AND gate using biological elements, I would need a form a circuit in the cell, whose output depends on two inputs and which only gives an output in the presence of both the inputs. In this case, both inputs need to be different *i.e.* both inputs are either different chemicals or one is a chemical and the other is heat/light. An interesting application of such a circuit is to create a toggle-switch. Researchers have been able to create a toggle switch using two cross-coupled transcription factors, each of which represses the other. Activation of one transcription factor leads to repression of the other, thus allowing one to toggle between the two. The expression of both Transcription Factor 1 (TF1) and Transcription Factor 2 (TF2) are regulated by two different input signals, say, for example TF1 is controlled by heat whereas TF2 is controlled by IPTG. Now, if the cell was subjected to a higher temperature than usual, one would observe expression of TF1 only and if the cell was grown in a media containing IPTG, one would observe expression of TF2 only. Thus, based on which transcription factor is required, the researcher can switch between the two by using heat or IPTG as a remote. Moreover, such genetic circuits could be transferred from mother to the daughter cells over many generations, thus implying that cells can not only be used to compute functions but can also be used for storing memory.

Conclusion

Based on the certain arguments, it is seemingly clear that use of genetic circuits offers better regulation as well as control, and offer more programmability than vector-based genetic manipulations in GMOs. I also believe that cells are digital in nature and can yield innumerable therapeutic, environmental, industrial and agricultural applications in future, based on computational approaches. The fact that cell could be in one out of two states *i.e.* either alive or dead, or the fact that DNA could be present in either 3'-5' or 5'-3' orientation represents binary language. This implies that if we were to assign a binary value, say 0 to any one of the orientations of a DNA sequence, then the DNA could be switched from binary value of 0 to 1, by simply inverting the sequence from 3'-5' to 5'-3' direction using recombinases.

References

1. Ahmad HI, Ahmad MJ, Asif AR, Adnan M, Iqbal MK, et al. (2018) A review of CRISPR-based genome editing: Survival, evolution and challenges. Curr Issues Mol Biol 28: 47-68.
2. Ajikumar PK, Xiao WH, Tyo KE, Wang Y, Simeon F, et al. (2010) Isoprenoid pathway optimization for Taxol precursor overproduction in *Escherichia coli*. Science 330: 70-74.
3. Benner SA (2010) Defining life. Astrobiology 10: 1021-1030.
4. Cambray G, Guimaraes JC, Mutalik VK, Lam C, Mai QA, et al. (2013) Measurement and modeling of intrinsic transcription terminators. Nucleic Acids Res 41: 5139-5148.
5. Carothers JM, Goler JA, Juminaga D, Keasling JD (2011) Model-driven engineering of RNA devices to quantitatively program gene expression. Science 334: 1716-1719.
6. Caschera F, Bedau MA, Buchanan A, Cawse J, de Lucrezia D, et al. (2011) Coping with complexity: Machine learning optimization of cell-free protein synthesis. Biotechnol Bioeng 108: 2218-2228.