> The work on restriction nucleases not only permits us easily to construct recombinant DNA molecules and to analyze individual genes, but also has led us into the new era of synthetic biology where not only existing genes are described and analyzed but also new gene arrangements can be constructed and evaluated.[12]

A notable advance in synthetic biology occurred in 2000, when two articles in Nature discussed the creation of synthetic biological circuit devices of a genetic toggle switch and a biological clock by combining genes within *E. coli* cells.[13][14]

Perspectives

Engineering

Engineers view biology as a *technology* – a given system's *biotechnology* or its *biological engineering*.[15] Synthetic biology includes the broad redefinition and expansion of biotechnology, with the ultimate goals of being able to design and build engineered biological systems that process information, manipulate chemicals, fabricate materials and structures, produce energy, provide food, and maintain and enhance human health (see Biomedical Engineering) and our environment.[16]

Studies in synthetic biology can be subdivided into broad classifications according to the approach they take to the problem at hand: standardization of biological parts, biomolecular engineering, genome engineering. Biomolecular engineering includes approaches which aim to create a toolkit of functional units that can be introduced to present new technological functions in living cells. Genetic engineering includes approaches to construct synthetic chromosomes for whole or minimal organisms. Biomolecular design refers to the general idea of de novo design and additive combination of biomolecular components. Each of these approaches share a similar task: to develop a more synthetic entity at a higher level of complexity by inventively manipulating a simpler part at the preceding level.[17]

Re-writing

Re-writers are synthetic biologists interested in testing the irreducibility of biological systems. Due to the complexity of natural biological systems, it would be simpler to rebuild the natural systems of interest from the ground up; In order to provide engineered surrogates that are easier to comprehend, control and manipulate.[18] Re-writers draw inspiration from refactoring, a process sometimes used to improve computer software.

Enabling technologies

Several novel enabling technologies were critical to the success of synthetic biology. Concepts include standardization of biological parts and hierarchical abstraction to permit using those parts in synthetic systems.[19] Basic technologies include reading and writing DNA (sequencing and fabrication). Measurements under multiple conditions are needed for accurate modeling and computer-aided-design (CAD).

Standardized parts

The most used[20]:22 – 23 standardized DNA parts are BioBrick plasmids, invented by Tom Knight in 2003.[21] Biobricks are stored at the Registry of Standard Biological Parts in Cambridge, Massachusetts. The BioBrick standard has been used by thousands of students worldwide in the international Genetically Engineered Machine (iGEM) competition.[20]:22 – 23

2. W97 binnenwerk-8 - Rathenau Constructing Life 2006.pdf (http://www.synbiosafe.eu/uploads/pdf/Rathenau%20Constructing%20Life%202006.pdf)
3. "Synthetic biology: promises and perils of modern biotechnology" (http://www.marsilius-kolleg.uni-heidelberg.de/marsilius-academy/index.html). Marsilius Academy Heidelberg - Summer school. Heidelberg University. Retrieved 2014-09-11.
4. Nakano, Tadashi; Eckford, Andrew W.; Haraguchi, Tokuko (12 September 2013). Molecular Communication (https://books.google.com/books?id=uVhsAAAAQBAJ). Cambridge University Press. ISBN 978-1-107-02308-6.
5. "Registry of Standard Biological Parts" (http://parts.igem.org/Main_Page). Retrieved 2014-09-11.
6. Hayden, EC (2014). "Synthetic-biology firms shift focus" (http://www.nature.com/news/synthetic-biology-firms-shift-focus-1.14602). Nature. 505 (7485): 598. doi:10.1038/505598a (https://doi.org/10.1038%2F505598a). PMID 24476868 (https://www.ncbi.nlm.nih.gov/pubmed/24476868). Retrieved 2014-09-11.
7. Osbourn, Anne E.; O'Maille, Paul E.; Rosser, Susan J.; Lindsey, Keith (2012-11-01). "Synthetic biology" (http://onlinelibrary.wiley.com/doi/10.1111/j.1469-8137.2012.04374.x/abstract). New Phytologist. 196 (3): 671–677. doi:10.1111/j.1469-8137.2012.04374.x (https://doi.org/10.1111%2Fj.1469-8137.2012.04374.x). ISSN 1469-8137 (https://www.worldcat.org/issn/1469-8137).
8. Théorie physico-chimique de la vie et générations spontanées, S. Leduc, 1910 (http://openlibrary.org/books/OL23348076M/Théorie_physico-chimique_de_la_vie_et_générations_spontanées)
9. Leduc, Stéphane (1912). Poinat, A., ed. La biologie synthétique, étude de biophysique (http://www.peiresc.org/bstitre.htm).
10. Dirk Stemerding, Virgil Rerimassie (2013). Discourses on Synthetic Biology in Europe (https://www.rathenau.nl/en/file/59/download?token=W_76_A_V). The Hague: Rathenau Instituut. p. 4.
11. "Panel discussion". Proceedings of the Eighteenth Annual "OHOLO" Biological Conference on Strategies for the Control of Gene Expression held March 27•30, 1973, at Zichron Yaakov, Israel (https://books.google.com/books?id=GC3vBwAAQBAJ). Advances in Experimental Medicine and Biology, v. 44. p. 405. doi:10.1007/978-1-4684-3246-6 (https://doi.org/10.1007%2F978-1-4684-3246-6). ISBN 978-1-4684-3248-0.
12. Szybalski, W; Skalka, A (November 1978). "Nobel prizes and restriction enzymes" (http://webarchive.loc.gov/all/20050822045428/http://www.sciencedirect.com/science?_ob=IssueURL&_tockey=%23TOC%236038%239999%23999999999%2399999%23FLA%23&_auth=y&view=c&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=31298e7170614a53f7839e91e65ac7c6). Gene. 4 (3): 181–2. doi:10.1016/0378-1119(78)90016-1 (https://doi.org/10.1016%2F0378-1119%2878%2990016-1). PMID 744485 (https://www.ncbi.nlm.nih.gov/pubmed/744485). Archived from the original (http://www.sciencedirect.com/science?_ob=IssueURL&_tockey=%23TOC%234941%231978%23999959996%23383739%23FLP%23&_auth=y&view=c&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=cf7bbc6f0e4d37c1de98c80fc9b50a3e) on 2005-08-22.
13. Elowitz, Michael B.; Leibler, Stanislas (January 2000). "A synthetic oscillatory network of transcriptional regulators" (http://www.nature.com/doifinder/10.1038/35002125). Nature. 403 (6767): 335–338. doi:10.1038/35002125 (https://doi.org/10.1038%2F35002125). PMID 10659856 (https://www.ncbi.nlm.nih.gov/pubmed/10659856).
14. Gardner, Timothy S.; Cantor, Charles R.; Collins, James J. (January 2000). "Construction of a genetic toggle switch in Escherichia coli" (http://www.nature.com/doifinder/10.1038/35002131). Nature. 403 (6767): 339–342. doi:10.1038/35002131 (https://doi.org/10.1038%2F35002131). PMID 10659857 (https://www.ncbi.nlm.nih.gov/pubmed/10659857).
15. Zeng, Jie (Bangzhe). "On the concept of systems bio-engineering". Coomunication on Transgenic Animals, June 1994, CAS, PRC. 6.
16. Chopra, Paras; Akhil Kamma. "Engineering life through Synthetic Biology" (http://www.bioinfo.de/isb/2006/06/0038/). In Silico Biology. 6. Retrieved 2008-06-09.
17. Channon, Kevin; Bromley, Elizabeth HC; Woolfson, Derek N (August 2008). "Synthetic Biology through Biomolecular Design and Engineering". Current Opinion in Structural Biology. 18 (4): 491–8. doi:10.1016/j.sbi.2008.06.006 (https://doi.org/10.1016%2Fj.sbi.2008.06.006). PMID 18644449 (https://www.ncbi.nlm.nih.gov/pubmed/18644449).