Synthetic and Molecular Biology

by Lorna D. McLeod

Synthetic biology as yet has no widely accepted definition. Nevertheless, the many definitions in use have some common key components: design or redesign, build or construct, biological systems: new or existing. At its core, synthetic biology is, to quote a high-level expert group of the European Union, “the engineering of biology” (1). A great deal is being written and debated about various ethical issues related to synthetic biology. But the Synthetic and Molecular Biology session at the June conference of the European Society for Animal Cell Technology (ESACT) in Dublin, Ireland will focus on the science, with presentations discussing tools and current research.

A 2008 telephone survey by the Wilson Center showed that many people (Americans, at least) have heard little or nothing about synthetic biology, but that’s about to change. According to Harvard Science Foundations, “Harvard scientists have cleared a key hurdle in the creation of synthetic life” (2). George Church, a genetics professor at Harvard Medical School, and Research Fellow Michael Jewett succeeded in creating synthetic ribosomes, a key component in all living systems. Although Church and Jewett created the ribosomes with industrial applications in mind, the potential for creating “artificial life” hasn’t been overlooked; a ScienceNews article was titled “Toward Synthetic Life” (3). A Daily Mail article on the same event led with “Artificial life could be created within FIVE years, experts claim” (4).

Researchers in India recently reported using synthetic biology and Escherichia coli fermentations to produce record amounts of amorphadiene, a precursor of the antimalarial agent artemisinin (5). Currently, artemisinin is plant-derived, creating seasonal fluctuations in the supply and the price of the first-line malaria treatment. A semisynthetic version, it is hoped, would stabilize the supply and the price, making malaria treatment more reliable.

At the University of California at Berkeley, chemists assembled different types of genetically engineered cells into synthetic microtissues that can perform functions such as secreting and responding to hormones, promising more complex biological capabilities than a single cell alone could produce (6). The same technology may eventually produce artificial organs, perhaps even as substitutes for human organs. And a University of California biochemist at Santa Cruz is watching developments in synthetic biology for the clues it may provide to the origins of life on Earth (7).

Among the groups studying both the science and the issues of this emerging science is The Synthetic Biology Project (www.synbioproject.org). The project was established in December 2008 as an initiative of the Foresight and Governance Program of the Woodrow Wilson International Center for Scholars in Washington, DC. Its work is supported by a grant from the Alfred P. Sloan Foundation of New York, NY (www.sloan.org). Initiative partners include the Hastings Center in Garrison, NY (www.thehastingscenter.org) and the J. Craig Venter Institute of Rockville, MD and San Diego, CA (www.jcvi.org). The project’s goal is to foster informed public and policy discourse concerning the advancement of synthetic biology, which it defines as “an emerging interdisciplinary field that uses advanced science and engineering to make or redesign living organisms, such as bacteria, so they can carry out specific functions.” The project adds, “Synthetic biology involves making new genetic code, also known as DNA, which does not already exist in nature” (8).

According to The Synthetic Biology Project’s website, the project will collaborate with researchers, governments, industries, nongovernmental organizations, policymakers, and others to “identify gaps in our knowledge of the potential risks of synthetic biology, explore public perceptions towards the field, and examine governance options that will both ensure public safety and facilitate innovation” (9).

Molecular Biology

The field of molecular biology overlaps with other areas including biology and chemistry — and especially with the subfields of genetics and biochemistry. It is, as the term implies, biology at the molecular level. This science looks at the relationships among cells and their biological systems. Of particular interest are interactions between and among

- the proteins that make cells work
- the DNA and RNA that make each living thing unique
- the protein biosynthesis mechanisms within and among
Cells. How all such interactions are regulated is also important. Among other things, molecular biology studies the chemical underpinnings of the process of replication, which includes the transcription and translation of genetic material. Its central (original) dogma, first enunciated by Francis Crick in 1958, states that information cannot be transferred back from protein to either protein or nucleic acid (10). That is today considered an oversimplification because of emerging novel roles for RNA.

Because it is a hybrid science, molecular biology uses tools from biology and chemistry and from the newer fields of genetics and biochemistry. The lines between all these fields are blurry, at best, and getting more so every day.

Molecular biology was “born” in the 1930s, with the term coined by Warren Weaver (then director of Natural Science for the Rockefeller Foundation) in 1938 (11). Beginning in the late 1950s, molecular biologists learned to characterize, isolate, and manipulate the molecular components of cells and organisms including DNA, RNA, and proteins.

One of the most basic molecular biology techniques — despite its oft misunderstood, science-fiction aura — is expression cloning. DNA coding for a protein of interest is cloned into a plasmid, an extrachromosomal DNA molecule capable of replicating independent of the chromosomal DNA within a suitable host. Introducing DNA into animal or other eukaryotic cells is called transfection. Several methods are in use, including calcium phosphate transfection, electroporation, microinjection, and liposome transfection. DNA can also be introduced into animal cells using viruses or bacteria carriers. The plasmid may be integrated into the genome for a stable transfection that will be passed on in future replications, or it may remain independent of the genome for transient transfection, as with insect cell culture using the baculovirus expression vector system (12).

Entire new fields related to molecular biology have emerged in recent years, including bioinformatics and computational biology that blend computer sciences with molecular biology, and molecular genetics, the study of gene structure and function.

**References**


**SESSION ONE: SYNTHETIC AND MOLECULAR BIOLOGY**

Session chairs are Martin Fussenegger and Hansjörg Hauser.

"New Tools for Designing, Building and Engineering Biological Systems" by Brian Baynes

"Engineering CHO Production Phenotypes by Specific Modification of Microrna Expression Levels" by Niall Barron

"Improvement of Monoclonal Antibody Production Processes by Host Cell Engineering" by Lore Florin

"The Use of Unconventionally High Codon Adaptation to Dramatically Improve Biopharmaceutical Cell Line Development Timelines and Titres" by Nina Kotsopoulou

"Short-Read Sequencing Reveals Dynamic Range of Transcript Abundance in CHO Cells" by Faraz Yusufi

"Synthetic Oscillatory Networks in Mammalian Cells" by Marcel Tigges

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5 Artemisinin-Based Combination Therapies for Malaria Treatment. MedIndia.com 2 March 2009; www.medindia.net/news/Artemisinin-Based-Combination-Therapies-For-Malaria-Treatment-48104-1.htm.


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**FOR FURTHER READING**


Shi J, Yang J. Transient Gene Silencing in NS/0 Suspension Cell Culture By siRNA. BioProcess Int. 5(9) 2007: 72–75.


**Lorna D. McLeod** is a consulting editor for BioProcess International.