Features

Bio-engineering the future?
Monday, September 14, 2009

Synthetic biology (SB) is the design and construction of new biological systems not found in nature. It aims at creating novel organisms for practical purposes but also at gaining insights into living systems by reconstructing them. SB is developing rapidly as a new interdisciplinary field, involving microbiology, genetic engineering, information technology, nanotechnology, and biochemistry. SB as a scientific and engineering field includes the following subfields:
• Engineering DNA-based biological circuits, including but not limited to standardised biological parts;
• Defining a minimal genome/minimal life (top-down approach);
• Constructing so-called protocells, ie. living cells, from scratch (bottom-up approach);
• Creating orthogonal biological systems based on a biochemistry not found in nature; and
• Production of gene fragments and genes by DNA synthesis machines.

With many anticipated benefits, the societal aspects of this discipline, as well as its possible risks, are becoming increasingly prominent. It is therefore crucial that the societal dimensions develop side by side with the field.

Old wine in new bottles?
Following the debate about the societal issues of SB, it seems that many 'old' issues resurface, which have been discussed for over 30 years now since the 1975 Asilomar Conference on Recombinant DNA. But as the contemporary political and societal contexts are quite different compared to the mid-1970s, old issues may be renegotiated in the light of this contemporary context. We also find, however, a number of new issues that are different from those associated with other life science activities.

Biosecurity challenges
Among these new issues is the risk of mail-ordered DNA from pathogens. With the availability of genetic sequence information available on the internet and outsourcing of DNA synthesis to specialised synthesis companies, we are facing the risk that some person with malicious intents might place an order for pathogenic genes. That this is a real risk has been demonstrated through the complete chemical synthesis of the polio-virus and the 1918 Spanish flu virus in 2002 and 2005 respectively. There are, of course, strict regulations that DNA synthesis companies must not send pathogenic DNA to any one person. The challenge is therefore not with regulatory imprecision but rather with the detection of pathogenic DNA sequences when handling several hundred orders per day. Science and industry have started to address this problem, aiming at the cooperation of DNA synthesis companies in screening orders to avoid inadvertent production of certain pathogens and/or parts thereof, and further developing and improving the technical means (eg. software, databases) used to screen for DNA orders.

These initiatives, driven by the International Consortium for Polynucleotide Synthesis (ICPS) and the International Association of SB (IA-SB), however, need to take into consideration not only the situation in Europe and the US, but – in the age of global outsourcing – need to obtain a truly global perspective considering also China, Japan, South Korea, India, Russia, etc.

Democratisation of biotechnology
The aim of SB is to make biology easier to engineer, which also means that in the future, more and more people should be able to design and construct biological systems. The annual student competition IGEM (International Genetically Engineered Machines, held in Boston), for example, gathers student groups from universities around the world to design and construct new biological systems, such as biosensors for environmental toxins, a beer containing the anti-ageing protein resveratrol from red wine, or E. coli producing a wintergreen smell. The various IGEM projects use the MIT-based Registry of Standard Biological Parts. This registry aims to provide biological parts (DNA sequences) with defined functions that can be plugged together in a cell to carry out specific tasks. A spin-off from IGEM is the DIY Bio (Do-it-yourself-biology) group in Boston – which also uses this registry – that wants to 'get biotech out of the lab and into your life'. So far, apart from a small circle of (bio-)hackers who welcome the democratisation of biotechnology, DIY Bio has mainly met raised eyebrows – rationally supported by biosafety concerns, whether or not bio-hackers put themselves and the community around them at risk. By properly taking the biosafety concerns into account, the democratisation of biotechnology might, however, lead to a similar creative revolution as seen in the computer industry and the internet.

Orthogonal systems
Of course, SB is not only about risks; it may also be recognised by its potential to make biotechnology even safer. The ability to design and construct biological systems with a much higher degree of precision and accuracy could easily lead to the implementation of a variety of novel biological safety systems. One example is the design of a minimal organism that has the smallest possible number of genes (a minimal genome) and because of that, could absolutely not survive outside a very specific laboratory environment. An even larger constrain for these designer organisms would be the implementation of a biological firewall that could separate engineered biological systems from the natural world.

The creation of orthogonal biological systems, such as those using non-standard ATGC base-pairs, or non-DNA non-RNA nucleic acids, so-called xenonucleic acid (XNA), lay the foundation for an unprecedented parallel world that cannot exchange genetic information with the natural world.

Stakeholder involvement
Since developments in SB are so rapid and regulation alone is no guarantee against misuse or societal controversies, it is necessary to involve relevant stakeholders (such as scientists, regulators, members of civil society, industry representatives, philosophers, and other relevant groups) in the discussion and the decision-making process. The interplay of different scientific disciplines in SB should be mirrored by the collaboration of different stakeholders to make sure this endeavour is safe enough and as successful as possible.

Further information:
'Synthetic Biology: The technoscience and its societal consequences' Schmidt M; Kelle A; Ganguli-Mitra A; de Vriend H (Eds.) 2009, Approx. 320 p., Hardcover, ISBN: 978-90-481-2677-4. www.springer.com/biomed/book/978-90-481-2677-4
'SYNBIOSAFE: Synthetic biology and its social and ethical implications'. Produced by Markus Schmidt and Camillo Meinhart. DVD, 35 minutes, English. www.synbiosafe.eu/dvd