March 2007 Horizon scanning SR010

HSE Horizon Scanning Intelligence Group Short Report

Synthetic biology

1. Issue

Status: Active Monitoring

Synthetic biology describes an emerging technique that uses genetic engineering to create organisms to perform novel tasks.[1] Current work is focusing on assembling genes from different organisms to create new metabolic pathways or new organisms. Eventually it may involve re-writing the genetic code, creating material beyond the range of current biology.[2]

Synthetic biology can be described as:
'The design and construction of new biological parts, devices and systems, and the redesign of existing, natural biological systems for useful purposes'.[3]

The main difference between conventional genetic engineering and synthetic biology is that conventional genetic engineering involves the transfer of individual genes from one species to another; whereas synthetic biology aims to apply engineering principles to genetics to allow the construction of novel genomes from standard parts or from scratch, as one might construct an electronic circuit from electrical components.[4] These standardised parts can be:

- natural genes applied for a new purpose;
- redesigned, more efficient natural genes;
- artificially designed and synthesised genes.

2. Background

Market analysts estimate the current research market for synthetic biology is £308 million and the potential for growth in the next 10 years is projected to expand this market to over £1.8 billion.[5] However there is concern about the safety of novel constructed organisms.

Developments in synthetic biology include; viruses that have been constructed from scratch - in 2002 a polio virus and in 2005 the extinct 1918 influenza virus.[4] Bacteria that act as photographic film,[6] bacteria that smell of banana or blink light on and off[7] and a bacterial colony that can play 'noughts and crosses'[8] have all been entrants in the International Genetically Engineered Machine competition, run annually since 2003 at Massachusetts Institute of Technology (MIT) in the USA. In 2004 a professional body was set up by MIT and Harvard University consisting of researchers in the field of synthetic biology.[3]

Research in synthetic biology has largely been pioneered by US groups so far, although a small number of UK universities including Cambridge and Imperial College are involved in this work.

[1] http://www.nytimes.com/2006/01/17/science/17synt.html?pagewanted=1&ei=5088&en=7cc85e36ab9c7aca&ex=1295154000
[2] http://www.economist.com/science/PrinterFriendly.cfm?story_id=7854314
[3] http://www.syntheticbiology.org/
[4] http://www.thenewatlantis.com/archive/12/tuckerzilinskasreferenced.htm
[5] http://www.researchandmarkets.com/reports/314528/synthetic_biology_a_new_paradigm_for.htm
[6] http://www.utexas.edu/opa/news/2005/11/nat_sci23.html
[7] http://www.technolohyreview.com/printer_friendly_article.aspx?id=17716
[8] http://parts2.mit.edu/wiki/index.php/Tokyo_Alliance:_Introduction

In addition four Pathfinder projects on synthetic biology have been funded in Europe under the FP6-2004-NEST-Path Programme.[9]

Although the construction of novel, useful and reliable microorganisms from a set of standardised parts is not likely in the near future (and this is just one goal of synthetic biology), work to achieve this is well underway. A registry of biological parts has been set up at MIT which aims to produce a library of standard genetic components (called 'biobricks') that can reliably perform a specific function and be connected to form novel genetic circuits.[10] This registry has recently received its 2000th contributor and can be freely used and added to by the public.[11]

Although in its infancy at present, synthetic biology has the potential to drive industry, research and employment in the life sciences in a way that could rival the development of the computer industry from the 1970s to the 1990s. Over the next 10 years synthetic biology may provide radical advances in areas such as; biomedicine, synthesis of biopharmaceuticals, sustainable chemical industry, environment and energy, production of smart materials/biomaterials and security (counter-bioterrorism).

3. Relevance to Health and Safety and Possible Implications

Synthetic microorganisms have the potential to reproduce and evolve; as such they could pose a risk to human health and the environment. However these organisms may not survive outside the laboratory due to their extensively modified genetic systems and special nutritional and environmental needs.

The risk associated with traditional genetic manipulation (GM) approaches can be estimated where the altered organism is equated with the natural version on which it is based. However, since synthetic biology aims to create novel organisms, these will contain extensively altered DNA and so they may be very different from organisms that exist in nature and it may be difficult to predict their characteristics or how they might evolve. Therefore it might not be appropriate to use this risk assessment approach.

Additionally, a significant number of researchers working in synthetic biology are not biologists but are engineers, computer programmers, and mathematicians.[12,13] As such they will have limited or no training in genetic modification and are unlikely to understand issues of biological exposure and biosafety; they are also not likely to fully understand the regulatory system surrounding these. This implies an increased health and safety risk (e.g. laboratory accidents, accidental release, accidental creation of an undesirable microorganism and possible COSSH issues). A new journal, IET Synthetic Biology; due to be launched in March 2007 by the Institute of Engineering and Technology aims to support workers and students entering the field of synthetic biology from other diverse areas.[14]

4. Recommendations

- Synthetic biology involves the genetic modification of microorganisms as such it is covered by HSE's GM regulations.
- However HSE needs to:
  - i. Be aware of the potential of synthetic biology activities to rapidly increase in the UK over the next 10 years.
  - ii. Consider the complex risks associated with use of this technology in workplaces.
  - iii. Ensure that there is suitable guidance in place.
  - iv. To be aware of the organisations and universities involved in synthetic biology.
- HSE's Horizon Scanning team and the Biological Agents group will continue to monitor advances in this area.

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[9] ftp://ftp.cordis.europa.eu/pub/nest/docs/pathfinder_projects_2003-2006.pdf
[10] http://openwetware.org/wiki/Main_Page
[11] http://www.biobricks.org/
[12] http://www.newscientist.com/channel/life/mg19025521.800-redesigning-life-meet-the-biohackers.html
[13] http://www.plantsci.cam.aco.uk/Haseloff/syntheticbiology/
[14] http://www.theiet.org/publications.journals/synbio/index.cfm