

# Synthetic biology: hope, hype or hazard?

**Helen Albert** (Editor)

While 'synthetic biology' was first coined as a theoretical term, arguably by French biologist Stéphane Leduc in 1910, actual physical application of the technique began in 2000. This was marked by publication of two papers in *Nature* on the creation of genetic switches in *Escherichia coli* allowing transition between two states based on some form of environmental trigger such as heat. Since then, synthetic biology has developed rapidly, underpinned by the genetic engineering revolution that has taken place over the last two decades. There is some debate about how to define this potentially transformative area of science, but in essence it involves using artificial design and engineering to modify biology, mostly on a molecular level, for purposes of improving applications for industry or biological research. It hit the news in 2003 when Craig Venter, probably its most notorious proponent, and colleagues managed to build a virus from scratch in 2 weeks, based on its published genome sequence. It returned to the limelight in 2010 when Venter and team told the world they had created 'the world's first synthetic life form' when they inserted a synthetic bacterial chromosome into a recipient cell to create a new self-replicating bacteria.

September 2015 saw the inaugural Synthetic Biology UK conference, jointly run by the Biochemical Society and the Royal Society of Biology (RSB). The event was deemed a great success by attendees who resoundingly voted for it to be a yearly affair. The conference will be hosted in Edinburgh next year.

The meeting took place over three days and covered a wide range of research ranging from the creation of novel DNA to the production of high-value chemicals using modified bacteria, among many other topics. Synthetic and astrobiologist Professor Lynn Rothschild (Brown University and NASA, USA) discussed in her keynote speech how synthetic biology can be used to underpin long-term human space presence by producing bespoke tools, food and organs on demand. The second keynote speaker was Professor Thomas Ward (University of Basel) who spoke about his research on creating novel metallo-enzymes to

expand the repertoire of chemical reactions available to biology. Applications of these enzymes could include DNA repair and bone regeneration.

While Synthetic Biology holds promise to solve problems that may otherwise be insurmountable such as feeding the Earth's rapidly expanding population, tackling health issues such as cancer and infectious disease and helping to break down man-made waste, it is still a largely unknown quantity and as such raises questions about what we could and should be using this technology for. Unusually, since ethical and safety concerns often lag behind research, this is an issue which was acknowledged and embraced by the synthetic biology research community at the outset, with funders such as the Biotechnology and Biological Sciences Research Council strongly encouraging consideration of wider societal issues.

To help promote discussion about this topic the Society ran a debate in collaboration with the RSB as part of Biology Week in October. Entitled 'Synthetic Life: How far could it go? How far should it go?' The debate was hosted by Dr Adam Rutherford and as well as a lively discussion session with the audience it involved talks from four speakers on different aspects of the topic.

Professor Robert Edwards (Newcastle University) spoke first on how important synthetic biology is likely to be for the future provision of food to an ever expanding human population. He was followed by Dr Louise Horsfall (University of Edinburgh) whose research focuses on using synthetic biology to achieve sustainable waste breakdown and who challenged society to become more focused on recycling and reusing what we consume. Professor Paul Freemont (Imperial College London) tackled the health and medical applications of synthetic biology and how it could impact our futures. Last but not least, the final speaker Dr Susan Molyneux-Hodgson (University of Sheffield) spoke about the ethics and sociology behind the science and challenged the audience to think about whether we focus on the process of synthetic biology or the product. ■

## Dr Louise Horsfall, University of Edinburgh



"Using biotechnology to manage our waste is not a new process. It's something that we are all doing, we are diligently collecting our kitchen waste and from

that we are producing fuel and energy that's being used right now. Synthetic biology offers ways to do this more efficiently and perhaps more robustly as well."

"We currently live in a linear economy and this planet has a finite amount of resources. The UK in 2012 was estimated by the green alliance to be 81% linear, so we are not recycling enough, we aren't re-using enough and we aren't re-manufacturing enough. Synthetic biology offers a whole new take on this, Not only could we use living systems to help recycle our biological nutrients, we could actually use synthetic biology to engineer living systems that also help us with the waste problems of non-biological nutrients."

## Dr Adam Rutherford (Chair of debate)



"We have of course been modifying biology for more than 10,000 years at a genetic level with farming, but in the 1970s there was a fundamental shift in how

we did that with the advent of genetic engineering and genetic modification and the ability to transfer a gene from one organism to another. Arguably the biggest shift was a conceptual one and was the application of engineering and mathematical principles into the modification of biology and that I think is the nearest we can get to a definition of synthetic biology."

## Professor Paul Freemont, Imperial College London



"The limits of synthetic biology will not necessarily be technical, but societal in that the applications and utility will need to be proven and accepted."

"There is a paradigm shift in how we are going to do biotechnology in the future, and that has happened because of two factors. One factor is the knowledge base we have accumulated over 40-50 years of very detailed biological research, the other factor is the ability to synthesise chemically large pieces of DNA in a relatively cost-effective way. So when we can rewrite the DNA programme chemically and order it and design it, then we are in a completely different world and I think this paradigm shift of how we do biotechnology is going to be created by synthetic biology."

## Professor Robert Edwards, Newcastle University



"We could think of synthetic biology as being one of a raft of different approaches that we can bring to bear to one of the most pressing demands that we have in

terms of a global challenge to mankind, that of our response to the food production challenge over the next 30 years.

"We need to fundamentally change the crops and the animals that we eat to better reflect the lifestyles that we live today. We eat too many calories but we have too few nutrients with it. We need to engineer our foods, perhaps in the first instance using conventional breeding, but as the challenges grow greater, perhaps we start to need to think about using synthetic biology to accelerate the rate at which we can improve our food and we can also input traits into agriculture making it more sustainable."

"We live on the edge of a trilemma, this depletion of resources, increasing population and an unstable climate and I put it to you that we have such major challenges in this whole sector that we would be very ill advised not to turn to synthetic biology amongst other important technologies to help us through the next few years."

## Dr Susan Molyneux-Hodgson, University of Sheffield



"If I had a lab, I suppose I might ask why is it that we continue to separate the technical and the social? Why is it that we continue to separate science from

ethics? And why is it that we continue to separate fact from values?"

"We expect the science will somehow produce results and then we can worry about ethics, legal, social stuff at the end."

"How should we go about deciding how far it should go? And it what direction? Who should have a voice in these debates and how should decisions be made?"

"Science can do things with synthetic biology. How successful these applications are is open to debate. Are we just doing something because we can or because we should?"