Game cards.

Synthetic Biology:

Dr. Liz Fletcher [1] and her colleagues at the University of Edinburgh's Centre [2] for Synthetic and Systems Biology (*SynthSys*) have developed a useful resource for students of National 5 and Higher Biology.

Dr Fletcher writes:
Synthetic biology is a new and highly multidisciplinary area of research that is quickly making its mark on our world. We've developed a card game that we hope will help learners to explore the many facets of this exciting, and sometimes controversial, area of science.

Over the past 5 years, the UK Government has invested over £300 million in accelerating the development of so-called synthetic biology. The University of Edinburgh was fortunate to win some of that funding and we are keen to share our excitement about participating in this fast moving area of science.

Synthetic biology is a new area of research that applies engineering principles to biology. Its goal is to (re-)design and fabricate biological components and systems that do not already exist in the natural world. Put another way, it views a living cell rather like a car engine where each component has a defined function; synthetic biologists then use these parts in different combinations to create new 'engines' (or cells) that can have new and improved functions. In theory, we could design and build completely new life forms.

Synthetic biology differs from genetic modification in both scale and ambition. Genetic modification generally refers to the transfer of individual genes from one organism to another; by contrast, synthetic biology aims to assemble, de novo, novel genomes using a set of standardized genetic parts.

Technical breakthroughs in the speed and cost of making DNA has accelerated this area of biology; it is now feasible and affordable to design and synthesize modified chromosomes of plants and microbes. Indeed, Edinburgh is now home to the Genome Foundry, a laboratory that uses robotics to build large stretches of DNA with minimal human input.

The field of synthetic biology is moving fast and has already had some striking successes. For example, researchers reconstructed the complex plant metabolic pathways of the herb Artemisinin and inserted it into yeast. In this way, they could manufacture the antimalarial drug Artemisinin by 'brewing' yeast rather than harvesting plants.

Other projects include engineering microbes to produce higher yields of oils (for biodiesel), novel medicines and brand new types of materials. Yeast is the most commonly used 'biofactory' but plants, algae, bacteria and even human cells can be 're-engineered' for different purposes. Indeed, researchers in our Centre are modifying human cells for use as cell-based treatments for conditions such as Parkinson's disease.

Hundreds of companies have been set up to turn these ideas into products and services. For example, a company called Synpromics, based at the Easter Bush Campus outside Edinburgh, is building tunable genetic controllers to help make gene therapy a reality. The US company Bolt Threads is making spider 'silk' proteins in yeast and then spinning these into fabrics. (You can, at a price, buy a tie made of spider's silk). Others are developing ways to make burgers without cows, by culturing muscle-producing cells in the lab.

For now, of course, much of our work is still very basic biology. Most of our scientists are using synthetic biology as a tool to 'learn by building' - getting deeper insights into how the natural world works by recreating it in the lab.

learning by playing cards

Last summer the Centre was fortunate to host an MSc student, Miss Ellie Powell, who worked to develop some classroom activities to support learning around synthetic biology. Ellie developed the 'What research would you fund?' card game and tested it with local schools. We hope it will educate, provoke and inspire your young people whether doing National 5 or Higher Biology. Synthetic biology is not without its controversies as you might expect for a technology that, at least in theory, seeks to do better than Nature. It raises some difficult questions: Just because we can, should we? Do the benefits outweigh the risks? Are some applications more acceptable that others, and why? How can we regulate such new technologies to protect consumers? Can we prevent this technology from misuse by criminals or terrorists? The card game highlights the importance of not just the science but also the wider social, political and economic environment in which researchers work and governments invest.

Another appealing aspect to synthetic biology is that it is a highly multidisciplinary requiring teamwork among individuals with expertise in biology, engineering, medicine (human and veterinary), computer science, art and design, physics, mathematics, chemistry, information and data science, and (not least) the social sciences.

Worksheet for students.

It also reflects an ongoing shift in both academic and industrial research away from subjects taught in traditional 'silos' towards much greater cross-discipline working. Indeed, it is at the interface between disciplines where the greatest innovation happens. As such, it is a great area for exploring teamwork and discussion, whatever the career aspirations of your young people.

I hope I have convinced you that it is worth finding out more about synthetic biology! We'd welcome feedback on the game [3] and if there are other ways we can support your teaching by introducing you to other areas of modern biology.

Thanks to Miss Ellie Powell (who did all the hard work), Mrs Kate Andrews of SSERC (for her guidance and advice), Mr Graham Russell (for his lovely artwork) and to the UK Research Councils and the University of Edinburgh who have help to fund the project.

Dr Liz Fletcher

References

[1] Dr Liz Fletcher, Centre Manager. e-mail liz.fletcher@ed.ac.uk, telephone 0131 650 7292.
[2] Centre websites: www.synbio.ed.ac.uk and www.synthsys.ed.ac.uk
[3] You can download the game from http://www.synthsys.ed.ac.uk/materials-teachers.