WHAT RESEARCH WOULD YOU FUND?

Teacher's Guide

This guide accompanies the 'What Research Would You Fund?' card game.

About the Activity

This activity involves learners in a discussion around the risks and benefits of funding different biological research projects that involve genetic engineering of living cells - a technology commonly referred to as ***synthetic biology***. (You can find further information about synthetic biology later in this Guide.) The activity is a card game that stimulates group discussion not just about the science but also its value and impact on society. It provides examples of exciting, potentially controversial, synthetic biology projects currently ongoing in labs across the world.

Curriculum links

Synthetic biology *per se* is not part of the curriculum but it encompasses a range of basic biological principles core to National 5, Higher Biology and Higher Human Biology.
You can use this activity to support teaching in the following curricula.
(Details on section links are outlined at the end of the Guide.)

- **NATIONAL 5 BIOLOGY**
  Cell Biology
- **HIGHER BIOLOGY**
  DNA and the Genome
  Metabolism and Survival
  Sustainability and Interdependence
- **HIGHER HUMAN BIOLOGY**
  Human Cells

THE UNIVERSITY of EDINBURGH

SynthSys Centre for Synthetic and Systems Biology

Developed by Miss Ellie Powell (MSc Student, School of Biological Sciences) and the Centre for Synthetic and Systems Biology, University of Edinburgh

Classroom set up

Students should work in teams of four around a table. Each team will need -

- A set of Funding Cards
- 1 Research Funding Worksheet - printed to A3
- 1 Policy Dice (but a class could share one.)
- Some pencils

Instructions

1. Ask the students to read the cards one at a time (in turn) to their team. The team can discuss what broad categories those projects come under (medicine, industrial/ consumer products, agriculture, and the environment). Each can then nominate a member to feedback the answer for one card colour to the whole class.

2. Next, each team must adopt the position of an imaginary government body and allocate funds to the projects. Each team must first discuss how they will manage this process. They should be encouraged to agree criteria among themselves before they start. Remind each team that they can choose to give all the money to just one project or fund all of them, but they must be able to justify their decision.

3. Team members can take it in turns to fill out the "Research Funding Worksheet", which asks them to consider the advantages, disadvantages and ethical considerations associated with each of their chosen projects. As they work through the process, they may wish to revise earlier decisions. Pencils might be advisable.

4. Ask the teams to feedback on their decisions; this provides an opportunity to see how much consensus there is across the class. Are some projects more contentious than others?

5. Task 2. If time permits, and for more advanced students, each team can throw a 'policy dice' to choose an additional criteria for their funding decision-making. They should then review the worksheet they completed before and discuss what changes they would make to their choice of funding allocations if they had to prioritise the projects on this policy alone.

Further Adaptations of the Activity

After the students have completed the tasks in their groups, they could be encouraged to do further research on the project ideas. For example, each group could be given one of the projects to research in more depth. They could then design a poster or Powerpoint presentation to better showcase the research and its applications.

Students could also be encouraged to design their own synthetic biology project and propose the idea to the class, which could then vote for the project with the greatest impact.

Examples questions to ask:

Q

Which project could provide the most good for society?

Which project is the most problematic from financial, ethical or practical reasons?

Which is your favourite project? Why?

Further Information:

An Introduction to Synthetic Biology

Synthetic biology is a new area of research that applies engineering principles to biology. Its goals is to (re-)design and fabricate biological components and systems that do not already exist in the natural world. Synthetic biology combines chemical synthesis of DNA with growing knowledge of genomics to enable researchers to quickly manufacture catalogues of DNA 'parts' and assemble them into new genomes. Improvements in the speed and cost of DNA synthesis mean that is now possible both technically and financially to design and synthesise modified chromosomes of plants and microbes. Researchers can then use synthetic biology to make the following:

- Standardised biological parts—to identify and catalog standardised genomic parts that can be used to build completely new systems;
- Design new protein—re-design existing biological parts to expand the range of natural protein functions;
- Manufacture natural products—engineer microbes to produce all of the necessary enzymes and biological functions so that they can make natural products previously only extracted from plants;
- Synthetic genomics—design and construct a 'simple' genome de novo.

What is the difference between synthetic biology and genetic engineering?

Genetic engineering usually involves the transfer of individual genes from one microbe or cell to another; synthetic biology is aiming to assemble, de novo, novel microbial genomes using a set of standardised genetic parts and then inserting this into a microbe or other cell.

Applications

The projects in the card game are categorised by colour according to their applications.
Cards with red backgrounds indicate medical or health related projects (medical biotechnology), brown cards indicate industrial applications (industrial biotechnology), blue cards denote environmental projects, and green cards represent agricultural projects. These reflect the very wide variety of applications for synthetic biology today.

Today, synthetic biology has driven the development of a thriving community of research labs and companies looking to deliver products and services.

- For example, they are using synthetic biology to produce a wide variety of novel chemicals for use as biofuels, bio-products, renewable chemicals, and bio-based specialty chemicals such as pharmaceutical intermediates, fine chemicals and food ingredients.
- Researchers are also working to re-engineer cells to become highly sensitive detectors of pollutants or pathogens to provide faster, more sensitive and more accurate diagnostics of agents harmful to humans and livestock.
- We can re-engineer human cells (including stem cells) in vitro to provide new ways of curing diseases through so-called cell therapy and regenerative medicine. In the USA, one of the first of these novel medicines (called immunotherapy) has just been approved for use in humans (see https://synbiobeta.com/synthetic-biology-immunotherapy-bring-effective-cell-therapies-cancer/)

Further Resources for Teachers

BioBuilder Educational Foundation http://biobuilderedu.wpengine.com/education/for-teachers/

National Informal STEM Education Network has useful resources on the engineering mosquitoes and 'gene drives'.

http://www.nisenet.org/catalog/should-we-engineer-mosquito-forum

Has some great case studies of the diverse applications of synthetic biology for further discussion.

http://synbio.info/display/synbio/Understanding+Synthetic+Biology

More Details on Curriculum Links

NATIONAL 5 BIOLOGY
Cell Biology
6. Genetic Engineering
Genetic information can be transferred from one cell to another by genetic engineering.
Links also to Biology: Life on Earth 5. Food Production - GM plants

HIGHER BIOLOGY
Unit: DNA and the Genome
5. The Structure of the Genome
6. Mutations

7. Genetic Control of Metabolism
(b) Recombinant DNA technology, plasmids and artificial chromosomes.

8. Genomic sequencing
(a) Genomic sequencing — the sequence of nucleotide bases can be determined for individual genes and entire genomes.
(d) Personal genomics and health. Pharmacogenetics.
(f) Genetic technology.

Unit: Metabolism and Survival
6. Environmental control of metabolism
c) Control of metabolism through the addition of metabolic precursors, inducers or inhibitors to give a required product.
7. Genetic control of metabolism
(a) Wild strains of microorganisms can be improved by mutagenesis, selective breeding and culture or recombinant DNA.
8. Ethical considerations in the use of microorganisms — hazards and control of risks.

Unit: Sustainability and Interdependence
2. Plant and animal breeding
(a) Plant and animal breeding by manipulation of heredity
(f) Genetic technology.

Citizenship
Learners will develop citizenship skills, when considering the applications of biology on our lives, as well as environmental and ethical implications.

HIGHER HUMAN BIOLOGY
Human Cells
1. Division and differentiation in human cells
(c) Stem cells — embryonic and tissue (adult) stem cells.

(e) Research and therapeutic uses of stem cells

2. Structure and replication of DNA
(a) Structure of DNA
(b) Chromosomes consist of tightly coiled DNA and are packaged with associated proteins.
(c) Replication of DNA by DNA polymerase and primer.

3. Gene expression

Complete course Support Notes for National 5 Biology, Higher Biology and Higher Human Biology can be accessed via the SQA website www.sqa.org.uk

https://www.sqa.org.uk/files_ccc/CfE_CourseUnitSupportNotes_N5_Sciences_Biology.pdf

https://www.sqa.org.uk/files_ccc/CfE_CourseUnitSupportNotes_Higher_Sciences_Biology.pdf
https://www.sqa.org.uk/files_ccc/CfE_CourseUnitSupportNotes_Higher_Sciences_HumanBiology.pdf