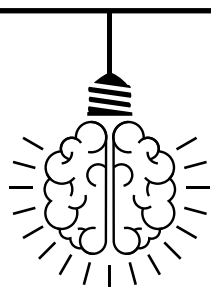




# Learning notes

- explore four of the key stories



Discover ideas, activities and opportunities to learn more about the science and technology covered in this edition of Catalyst magazine.

## Contents

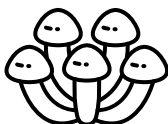
Curriculum Links

Valiant Vaccines  
Vanquish Viruses



1

Finding out about fungi



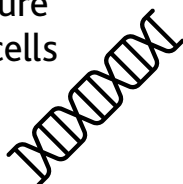
2

Discovering Careers



3

Tissue culture and stem cells



4

# Curriculum links

The articles in this issue of Catalyst are relevant to the curriculum for students aged 14 – to 19.

## Article - The medical devices we take for granted by Joseph Langley

### GCSE or equivalent and A level or equivalent Maths

- Basic mathematics – used daily by engineers
- Trigonometry - essential for calculation of forces in engineering components
- Calculus – used for more complex calculations for forces/stresses

### Design & Technology

- Product design process
- Solving problems in design and manufacture
- Using research to identify and solve design problems.
- Understanding the properties of materials and the performance of structural elements to achieve functioning solutions
- Developing and testing through prototypes

### Biology

- Musculoskeletal anatomy – bone, soft tissues, muscles
- Cells and the immune system

### Chemistry

- Elements and bonding types (informs materials science)

### T' Level Science

#### Core:

A2.2 The diversity of work undertaken in different job roles within the science sector

A2.8 The principles of good manufacturing practice (GMP) in ensuring that products

A2.12 How regulatory controls apply in different working environments within the science sector

A2.14 The importance and impact of innovation in the science sector

A3.1 The purpose of legislation and regulations in the health and science sector

A5.1 A range of methods used to collect data:

B1.33 The relationship between the atomic structure and physical and chemical properties of metals

CS6.1 Provide results and recommendations (written and verbal) to customers/clients

CS7.1 Evaluate a project's processes and outcomes

### Lab sciences:

K1.28 How the properties of the following materials are related to their applications

K1.54 The purpose of laboratory techniques used in the science manufacturing environment

K1.65 How the following regulations are applied when performing scientific techniques in a laboratory environment

K1.66 The role of standards and regulatory bodies (including industry specific) within a laboratory environment

K2.4 The principles of laboratory equipment validation when planning scientific tasks

## Article - Valiant Vaccines Vanquish Viruses by Jessica Kan

### GCSE or equivalent

#### Biology

- Treating, curing and preventing diseases

#### A level or equivalent

A level specifications from the different examination boards include:

- cell recognition and the immune system
- ethical issues associated with the use of vaccines

### T' Level Science

#### Core:

B1.27 How infectious diseases can spread amongst populations and communities:

B1.28 The definition of an antigen and an antibody:

- antigen – a substance that is recognised by the immune system as non-self and stimulates an immune response
- antibody – a blood protein produced in response to, and counteracting, a specific antigen.

B1.29 The link between antigens and the initiation of the body's response to invasion by a foreign substance:

- antigens as chemical markers
- ability of the body to recognize self and non-self-antigens.

B1.30 The stages and cells involved in the body's response to an antigen, including:

- phagocytosis
- actions of T-cells
- actions of B-cells.

B1.31 The differences between cell-mediated immunity and antibody-mediated immunity including:

- cell-mediated response is associated with T-lymphocytes destroying causative agents without producing antibodies
- antibody-mediated response is associated with B-lymphocytes destroying causative agents by producing antibodies against it.

### **Article - How can you work on medical devices? by Joseph Langley**

#### **GCSE or equivalent**

##### **Design & Technology**

- Product design process
- Solving problems in design and manufacture
- Using research to identify and solve design problems.
- Understanding the properties of materials and the performance of structural elements to achieve functioning solutions
- Developing and testing through prototypes

##### **Careers**

- Supports Gatsby Careers Benchmark 4

#### **A level or equivalent and T' Level Science**

##### **Careers**

- Supports Gatsby Careers Benchmark 4

### **Article - Malaria and the future of mosquito control by Estela Gonzalez Fernandez**

#### **GCSE or equivalent and A level or equivalent**

##### **Biology**

- Communicable diseases

##### **T' Level Science**

##### **Core:**

B1.24 The nature of infection

B1.25 Causative agents of infection and examples of resulting diseases

B1.26 The different ways in which causative agents may enter the body

B1.27 How infectious diseases can spread amongst populations and communities:

B2.14 Examples of different types of pathogens and the diseases they can cause:

##### **Lab sciences:**

K1.34-1.35 Genotyping and Phenotyping

K1.56 The purpose of techniques, particularly those related to genomics

K1.64 The purpose of analysis methods to produce reliable and verifiable results when dealing with large sets of data in genomics

### **Article - Beating COVID-19: The remarkable RECOVERY Trial by Dr Caroline Wood**

#### **GCSE or equivalent**

##### **Biology**

- body defences against pathogens and the role of the immune system against disease
- the process of discovery and development of new medicines

#### **A level or equivalent**

##### **Biology**

- communicable diseases and the immune system
- vaccines and vaccination programmes

##### **T' Level Science**

##### **Science Core Component**

- The diversity of work undertaken in different job roles within the Science sector (including research and clinical testing/trials)
- Links between sample size and effective statistical analysis
- Immunology: the nature of infection including viruses

##### **Specific links:**

##### **Core:**

A2.1 Factors that contribute to the diversity of employers/organisations within the science sector

A2.2 The diversity of work undertaken in different job roles within the science sector

A2.6 The individual's responsibilities in relation to the wider team

A5.1 A range of methods used to collect data

A6.12 How to prevent or reduce bias in data evaluation

A6.13 Links between sample size and effective statistical analysis

B1.24 -1.32 Immunology

##### **Lab sciences:**

K1.3 The principles of the 'Universal Ethical Code for Scientists 2007' and how it affects ethical practices in a laboratory setting

## **Article - Tissue engineering: how it allows us to build organs in the laboratory by Dr Sara Campinoti**

**GCSE or equivalent**

**Biology**

- the fundamental units of living organisms are cells, which may be part of highly adapted structures including tissues, organs and organ systems, enabling life processes to be performed more effectively
- stem cells in animals
- the need for transport systems in multicellular organisms

**A level or equivalent**

**Biology**

- in complex multicellular organisms cells are organised into tissues, tissues into organs and organs into systems

**T' Level Science**

**Science Core Component**

- The importance and impact of innovation in the Science sector
- The principles of cell theory

**Specific links:**

**Core**

CS4 Creativity and innovation

B1.1 – 1.5 Cells and tissues

## **Article - Bringing science to life – what's it like to work as a scientific documentary researcher? An interview by Dr Caroline Wood**

**GCSE or equivalent, A level or equivalent and T' Level Science**

**Careers**

- Supports Gatsby Careers Benchmark 4

## **Article - Skin deep: modelling fungal skin infections by Dr Donna MacCallum**

**GCSE or equivalent**

**Biology**

- Cells
- Microorganisms
- Ethics
- DNA
- Gene expression

**A level or equivalent**

**Biology**

- Cells
- Electron microscopy
- Microorganisms
- Ethics
- DNA and protein synthesis
- Gene expression
- Second messengers

**T' Level Science**

**Core**

A1.3 The key principles of ethical practice in the health and science sectors

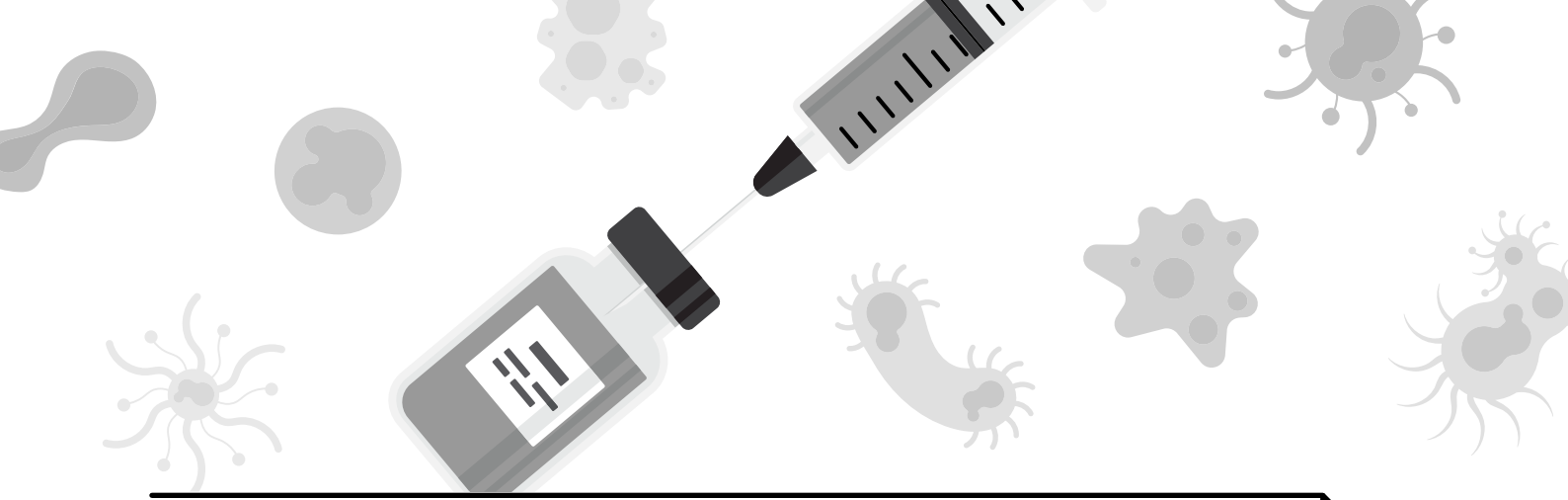
A7.1 -7.8 Ethics

B1.20 The classification and characteristics (size of cell, type of cell, presence of organelles) of microorganisms

B1.25 Causative agents of infection and examples of resulting diseases

B2.2 The role of DNA bases in the production of amino acid chains, which form proteins

B1.24-1.32 Immunology



## Learning notes

### Valiant Vaccines Vanquish Viruses

The author of this article talks about vaccinations – including different types, how they work, how they are developed, manufactured and the advantages/disadvantages of vaccinations. The article concludes by looking at the future of vaccinations and how the COVID-19 pandemic has demonstrated the need to turnaround vaccine development more swiftly. This topic lends itself to the consideration of ethics and how internationally agreed principles govern the development of new medicines.

#### Learning Task:

The Declaration of Helsinki Rules

Students consider what ethical rules they think should be in a declaration of medical ethics, such as the Declaration of Helsinki. Following discussion about what such a set of rules should contain, students participate in a true/false quiz about the Declaration of Helsinki. Finally, a discussion is held to ensure students understand the rationale behind the statements in the Declaration of Helsinki.

You will need:

A copy of the Declaration of Helsinki ([www.wma.net/policies-post/wma-declaration-of-helsinki-ethical-principles-for-medical-research-involving-human-subjects/](http://www.wma.net/policies-post/wma-declaration-of-helsinki-ethical-principles-for-medical-research-involving-human-subjects/))

A copy of the New Vaccines Workshop guide from Centre of the Cell – page 5 ([www.stem.org.uk/rx32ko](http://www.stem.org.uk/rx32ko))

- Ask students to make a list of ethical rules that they think a declaration of medical ethics, like the Declaration of Helsinki, should contain.
- Briefly discuss the students' reasons for choosing their rules and write ten or so suggestions on the board.
- Now read the statements about the Declaration of Helsinki (page 5-6 of New Vaccines Workshop guide), and ask the pupils to vote whether they think the statements are true or false.
- At the end of the quiz, reveal the answers and discuss the reasons why

#### Take your learning further:

Follow up questions and tasks to use with the class include:

Ask the class if any of these answers surprised them. Why or why not?

Distribute copies of the Declaration of Helsinki. Ask the class which parts of this declaration would have been violated by historical instances of vaccination (e.g. the work of Dr. Edward Jenner and Lady Wortley Montagu). Was it right to have no consideration for ethics? Why wasn't there any consideration for ethics back then? Could a lack of ethics ever be justified?

Ask the class to research the history of the Declaration of Helsinki and the reasons for the changes that have been made to it over the years.

### **Take your learning further still:**

The Declaration of Helsinki is not the only document that medical researchers apply to their research to ensure that it is ethically sound. The Good Clinical Practice guidelines, set down by the International Conference on Harmonisation, and laws of the country where trials take place also warrant consideration.

Ask students to research some of these other guidelines and write a report comparing them to the Declaration of Helsinki.

### **To find out more:**

Biointeractive have produced a short article that looks at why it's hard to make vaccines and boost supplies ([www.biointeractive.org/planning-tools/science-news/explainer-why-its-hard-make-vaccines-and-boost-supplies](http://www.biointeractive.org/planning-tools/science-news/explainer-why-its-hard-make-vaccines-and-boost-supplies))

Biointeractive have also produced a comprehensive interactive online tutorial on the immune system and vaccinations, which students can work through and self-assess their understanding ([www.biointeractive.org/classroom-resources/immune-system](http://www.biointeractive.org/classroom-resources/immune-system))



## Learning notes

### Finding out about fungi

Linked Article: [Skin deep: modelling fungal skin infections](#)

The author of this article talks about the importance of fungal infections on human skin and why they are difficult to study and treat. She explains why animal models, such as mice, are not suitable for studying fungal skin infections in humans and says that there are better ways to study this problem. She describes alternative non-animal experiment models.

The learning tasks below give you an opportunity to explore a model for testing anti-fungal treatments and information about understanding micro-organisms and disease.

#### Learning Task:

Inhibition zones and antifungals.

Use aseptic technique to set up a lawn or pour plate of the fungus baker's yeast and use it to investigate the action of possible anti-fungal substances such as athlete's foot cream and essential oils.

**Note:** you should carry out a risk assessment before doing the learning tasks suggested here.

You will need: per person or group:

- Petri dish containing sterile medium, such as malt extract agar to grow the yeast.  
**Note:** yeast will not grow well on nutrient agar. You could use yeast extract-peptone-dextrose agar (YPD or YEPD) or starch malt agar (SMA) instead of the malt extract agar
- Suspension of fast action baker's yeast made by mixing 1g of fast action yeast granules from the supermarket with 100ml of sterile water, left in a warm place or incubator for approximately 2 hours

- Sterile spreader
- Sterile syringe or Pasteur pipette
- Filter paper discs cut from filter paper using a hole punch
- Forceps or tweezers
- Substances to test for anti-fungal properties, for example: athlete's foot products – different brands; essential oils – try tea tree or clove oil; crushed garlic, onion or other alliums; disinfectants such as Dettol.

Instructions for aseptic technique setting up the plates can be found on [CLEAPSS website PPO50](#) (member log in required) or in GCSE Biology and A level practical Biology guidance from examination boards.

Information to support students to do micro-organism risk assessments can be found on CLEAPSS student safety sheet 01 Microorganisms [here](#).

#### Take your learning further:

Grow your own fungi – although this CLEAPSS resource is in their primary science section the technique could be adapted to explore the effect of changing variables such temperature [primary.cleapss.org.uk/Resource/P006-Growing-fungi-on-food.aspx](#)

The Society of General Microbiology also have information on fungi to explore and about growing fungi to look at their morphology [here](#).

Explore information from health services about fungi - NHS direct (UK health service) including photographs:

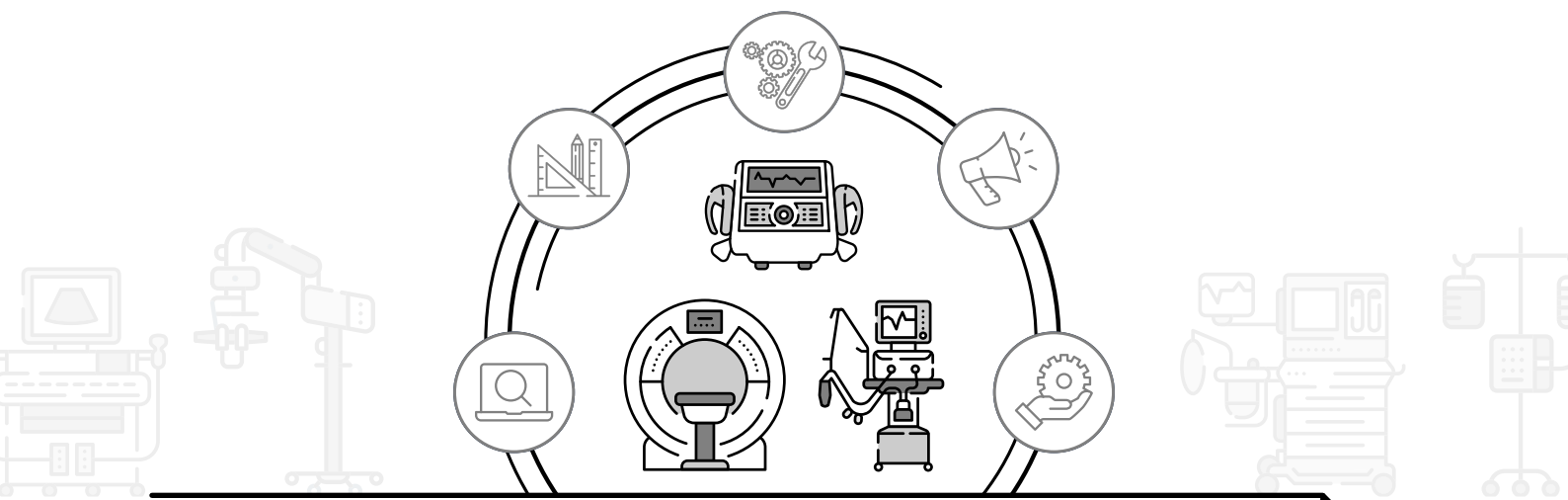
- ringworm [www.nhs.uk/conditions/ringworm](http://www.nhs.uk/conditions/ringworm)
- athlete's foot [www.nhs.uk/conditions/athletes-foot](http://www.nhs.uk/conditions/athletes-foot)
- fungal nail infection [www.nhs.uk/conditions/fungal-nail-infection](http://www.nhs.uk/conditions/fungal-nail-infection)

You may like to compare this with the advice and information given in another country, for example the US Centers for Disease Control and Infection fungal diseases pages: [www.cdc.gov/fungal/index.html](http://www.cdc.gov/fungal/index.html)

### **Take your learning further still:**

1. Read about the action and different effects of disinfectants using CLEAPSS student safety sheet 9 Disinfectants [science.cleapss.org.uk/resource/SSS009-Disinfectants.pdf](http://science.cleapss.org.uk/resource/SSS009-Disinfectants.pdf)
2. Make a time-lapse video to show fungal growth or decay using a mobile phone and an app – you can find tips [here](#).
3. Read information and classify disease causing microbes, according to criteria doctors use, information cards and images [here](#).





## Learning notes

### Discovering Careers

Linked Articles: [How can you work on medical devices?](#)

[Bringing science to life – what’s it like to work as a scientific documentary researcher?](#)

This edition of Catalyst explores the theme of human health. Whether it is looking at how vaccines work, the control of pathogens and fungal infections, exploring stem cells in the brain or engineering human replacement organs and joints. All the articles are linked by scientific research and development and showcase how STEM subject knowledge is vital in taking medical developments forward.

Each author has a career that engages STEM subjects in every aspect of their working day. Showcasing how important their work is and its impact on the world. It is clear how much they enjoy their work and the challenges they face each day using their creativity, logical thinking, and problem-solving skills to make a genuine difference.

When looking at career choices it is important to not only know what you want to do and how you will get there, but that your chosen career path will give you long lasting enjoyment and satisfaction.

#### Learning Task:

Here are three questions to consider and discuss with friends, teachers, and family.

1. Which of the articles appealed to you the most?
2. What about it inspired you?
3. Whose career would you most like to have and why?

#### Take your learning further:

Find out more about the many STEM related careers in this edition of Catalyst and investigate jobs that appeal to you. Here are some suggestions:

- Research the role of the author whose job appeals to you the most. What qualifications and experience might you need to do a similar career?
- Find out about the organisations the authors work for, what do they do? Can you see yourself working for those organisations, do they have opportunities you could get involved with?
- Choose a job that you are interested in and find out the qualifications you need to do that job. Which universities provide that qualification? Are there apprenticeships available?
- Ask your teacher or STEM Club leader if they could arrange for STEM Ambassadors to visit and give a talk about their work and how they got their jobs. Maybe you could interview them and hone some of your employability skills.
- Think about getting experience related to the role or project you are interested in such as summer placements or volunteer with similar organisations or projects. If you try it out you’ll know if it’s for you.
- Consider taking part in the Nuffield Research Placement programme and work with scientists on scientific research projects.
- Discuss with family and friends your career aspirations do they know anyone you could talk to with a similar role that you could get advice from?

Take every opportunity to research careers and jobs that interest you, ask around and seek advice. The more you find out, the easier it will be to choose the right path for you. And remember, it's ok to change your mind about a career and try something different.

### **Take your learning further still:**

The following websites have information about careers related to the article topics or are useful general careers guidance. Have a look and see what appeals!

Careers in medicine: [www.healthcareers.nhs.uk/sites/default/files/documents/Careers%20in%20medicine\\_1.pdf](http://www.healthcareers.nhs.uk/sites/default/files/documents/Careers%20in%20medicine_1.pdf)

Careers with a medical degree: [www.prospects.ac.uk/careers-advice/what-can-i-do-with-my-degree/medicine](http://www.prospects.ac.uk/careers-advice/what-can-i-do-with-my-degree/medicine)

Careers involving healthcare: [nationalcareers.service.gov.uk/job-categories/healthcare](http://nationalcareers.service.gov.uk/job-categories/healthcare)

Careers involving animal care: [nationalcareers.service.gov.uk/job-categories/animal-care](http://nationalcareers.service.gov.uk/job-categories/animal-care)

Medical engineering: [www.healthcareers.nhs.uk/explore-roles/healthcare-science/roles-healthcare-science/physical-sciences-and-biomedical-engineering/medical-engineering](http://www.healthcareers.nhs.uk/explore-roles/healthcare-science/roles-healthcare-science/physical-sciences-and-biomedical-engineering/medical-engineering)

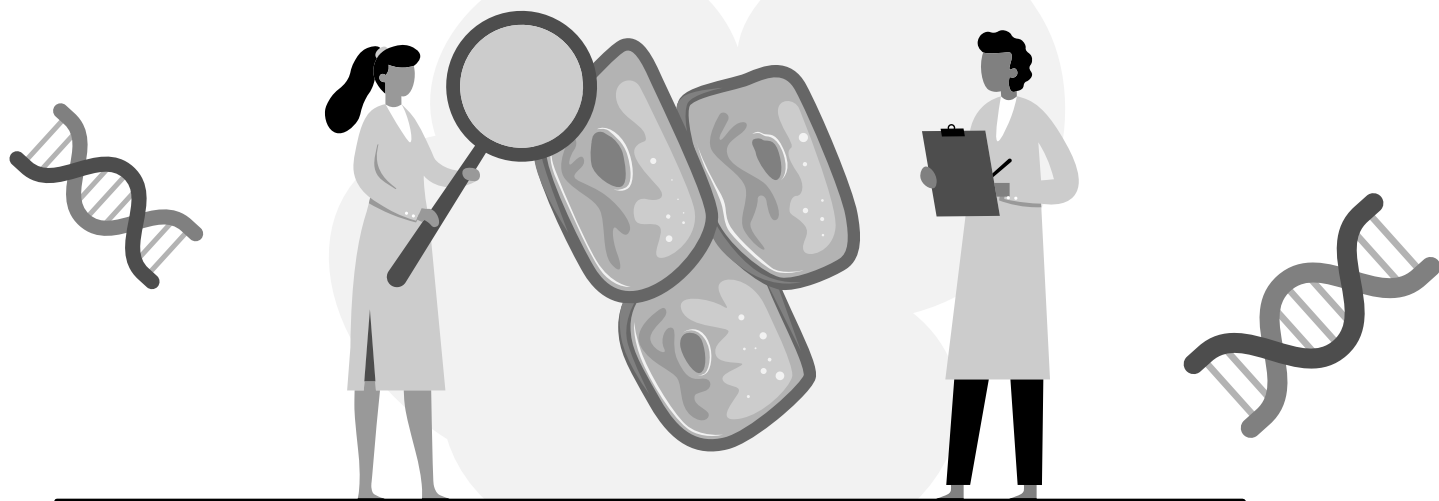
Medical research scientist: [www.prospects.ac.uk/job-profiles/research-scientist-medical](http://www.prospects.ac.uk/job-profiles/research-scientist-medical)

Film studies: [www.prospects.ac.uk/careers-advice/what-can-i-do-with-my-degree/film-studies](http://www.prospects.ac.uk/careers-advice/what-can-i-do-with-my-degree/film-studies)

Getting started in a film or television career: [www.thebalancecareers.com/how-to-get-started-in-a-film-or-television-career-1283521](http://www.thebalancecareers.com/how-to-get-started-in-a-film-or-television-career-1283521)

National Careers Service – [nationalcareers.service.gov.uk](http://nationalcareers.service.gov.uk)

STEM Learning: [www.stem.org.uk/stem-careers](http://www.stem.org.uk/stem-careers)



## Learning notes

### Tissue culture and stem cells

Linked Article: [Tissue engineering: how it allows us to build organs in the laboratory](#)

This article talks about the urgent need to address the problem of a shortage of organ donors and available organs, so that thousands of people waiting for life-saving replacement organs, such as hearts, kidneys or lungs can get the replacement organ they need. The article explains how scientists are working to build artificial body parts and discusses how this might be done through techniques using stem cells and tissue culture, amongst other methods.

#### Learning Task:

Carry out tissue culture for yourself using cauliflower.

This practical uses stem cells from a cauliflower plant rather than animal stem cells. It will help you to understand what a stem cell is and how they can be used to grow organs.

The technique is cheap, reliable and straightforward. It uses the liquid used to sterilise baby's bottles and is based on an approach developed by Kew Gardens to clone and protect a rare species of tree in a part of the world without many laboratory facilities.

You will need:

- cauliflower curd (the white 'flore' part)
- small sterilised containers
- growth medium (MS, 20g/l sucrose, 2.5mg/l Kinetin, 0.032% SDICN – see SAPS Teaching and Technical notes at this link for where to buy and how to prepare this.
- chopping board

- Forceps
- Scalpel
- small glass jars
- Milton tablets
- Deionised water
- Petri dish
- Safety glasses and disposable gloves
- Virkon disinfectant for wiping down tables

For details of the method, technical notes and a 'how to' video please see this Science and Plants for Schools, Cauliflower Cloning resource [www.stem.org.uk/rx34ju](http://www.stem.org.uk/rx34ju)

You can find an easy to follow picture guide to download for students - see Student Guide and more on the National Centre for Biotechnology Education (NCBE) website. It is also possible to buy Cauliflower Cloning Kits of equipment from this UK site. [www.ncbe.reading.ac.uk/MATERIALS/Plant%20science/cauliflower.html](http://www.ncbe.reading.ac.uk/MATERIALS/Plant%20science/cauliflower.html)

As with all practical activities in school you should carry out a risk assessment based on guidance from your local safety organisation – CLEAPSS, SSERC or your local relevant organisation.

#### Take your learning further:

Debate about using STEM Cells for medical treatment and consider the ethical, political and factual issues that stem cell treatments raise. Role play gives students a chance to explore the different sides of the issue and compare others' points of view. 'I'm a scientist...' debate kit [www.stem.org.uk/rx32jj](http://www.stem.org.uk/rx32jj)

All About STEM Cells has materials that explain where embryonic stem cells come from  
[www.stem.org.uk/rxzvp](http://www.stem.org.uk/rxzvp)

SSERC have case study style report cards with articles about different developments using stem cells, such as making human body parts [www.sserc.org.uk/subject-areas/interdisciplinary-learning/lets-talk/stem-cells/](http://www.sserc.org.uk/subject-areas/interdisciplinary-learning/lets-talk/stem-cells/)

### **Take your learning further still:**

You can find a detailed and well-illustrated booklet called, 'Stem cells – science and ethics' downloadable as a pdf, on the Biotechnology and biological sciences research council [website](#).

You may also like to read about the Nobel Prize for Medicine 2012 was awarded to John B. Gurdon and Shinya Yamanaka and download a summary poster from Nobel.org, as they say - 'The Nobel Prize recognizes two scientists who discovered that mature, specialised cells can be reprogrammed to become immature cells capable of developing into all tissues of the body. Their findings have revolutionised our understanding of how cells and organisms develop. Source: [www.nobelprize.org/prizes/medicine/2012/press-release](http://www.nobelprize.org/prizes/medicine/2012/press-release)



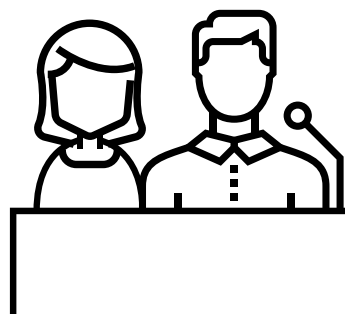
## Meet our authors and 1000's of inspiring STEM role models like them!

Many of the Catalyst authors are volunteers in the STEM Ambassadors programme.

STEM Ambassadors are inspiring volunteers from industry and university, situated across the UK who can support young people and educators by providing talks, mentoring and engaging STEM activities.

For example, you could request a STEM Ambassador to:

- provide an online talk for your class
- judge a STEM competition in your school or college
- attend a parents evening and talk about careers linked to STEM subjects
- run a practical activity for a STEM subject club



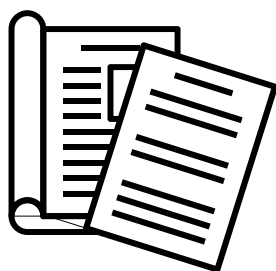
Bring the power and inspiration of STEM Ambassadors to your classroom, free of charge:

- visit the STEM Ambassador website ([www.stem.org.uk/stem-ambassadors](http://www.stem.org.uk/stem-ambassadors))
- use the STEM Ambassador app (search STEM Teacher on your app store).



If you need help getting started, contact your local STEM Ambassador Hub:

[www.stem.org.uk/stem-ambassadors/local-stem-ambassador-hubs](http://www.stem.org.uk/stem-ambassadors/local-stem-ambassador-hubs)



## Thank you

We hope you enjoyed Catalyst, and matching learning notes. If you have any feedback, or ideas for topics you'd like to see covered in future editions, please email:

[catalyst@stem.org.uk](mailto:catalyst@stem.org.uk)



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