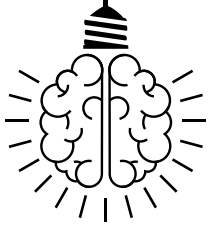
Learning notes

- 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

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

Article - The Peculiar Powers of Polarisation – in the natural world

Alan Denton

GCSE or equivalent

Biology

- Variation and evolution – 'recall that all variants arise from mutations, and that most have no effect on the phenotype, some influence phenotype and a very few determine phenotype'
- describe evolution as a change in the inherited characteristics of a population over time through a process of natural selection which may result in the formation of new species'
- 'explain how evolution occurs through natural selection of variants that give rise to phenotypes best suited to their environment'

Physics

- Light and electromagnetic waves - 'recall that light is an electromagnetic wave'
- 'recall that electromagnetic waves are transverse, are transmitted through space where all have the same velocity, and explain, with examples, that they transfer energy from source to absorber'
- 'describe the main groupings of the spectrum – radio, microwave, infra-red, visible (red to violet), ultra-violet, X-rays and gamma-rays, that these range from long to short wavelengths and from low to high frequencies, and that our eyes can only detect a limited range'

A-Level or equivalent

Biology

- Biodiversity – 'adaptation and selection are major factors in evolution and make a significant contribution to the diversity of living organisms'
- Genetics and evolution – 'transfer of genetic information from one generation to the next can ensure continuity of species or lead to variation within a species and possible formation of new species'

Physics

- Waves – 'qualitative treatment of polarisation and diffraction'
- 'path difference, phase and coherence, interference'
- 'graphical treatment of superposition and stationary waves'

Article - Maths in a cold climate

Steve Wroe

GCSE or equivalent

Mathematics

Number and proportion

- apply and interpret limits of accuracy when rounding or truncating, including upper and lower bounds
- compare lengths, areas and volumes using scale factors

Geometry and Measures

- interpret and use bearings
- apply Pythagoras' Theorem and trigonometric ratios to find angles and lengths in right-angled triangles
- apply addition and subtraction of vectors, multiplication of vectors by a scalar, and diagrammatic and column representations of vectors

A-Level or equivalent

Mathematics

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Article - It's not rocket science, or is it?

GCSE or equivalent

Physics

- Newton's Third Law
- Projectile motion
- Ratios
- Combustion

A-Level or equivalent

Physics

- Newton's Third Law
- Natural logarithms
- Combustion

Article - Inspired by maths

Amitkumar Shah MEng (Hons), AMIMechE

GCSE or equivalent

Maths

- Number
  - calculate exactly with fractions
- Algebra
  - use algebra to support and construct arguments and proofs
  - translate simple situations or procedures into algebraic expressions or formulae;
  - derive an equation(s) solve and interpret the solution
- Probability
  - use a probability model to predict the outcomes of future experiments;
  - understand that empirical unbiased samples tend towards theoretical probability distributions, with increasing sample size
  - calculate the probability of independent and dependent combined events
  - calculate and interpret conditional probabilities through different representations

Careers
Supports Gatsby Benchmark 4

A-Level or equivalent

Maths

- Number
  - calculate exactly with fractions
- Algebra
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  - translate simple situations or procedures into algebraic expressions or formulae;
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- Probability
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Careers
Supports Gatsby Benchmark 4

Article - Investigating the sleeping state of bacteria

Dr Sariqa Wagley

GCSE or equivalent

Biology

- Health, disease and the development of medicines

A-Level or equivalent

Biology

- It provides wider reading about prokaryotic cells and disease, as well as methods of counting bacterial cells.
- Adaptations of organisms to their environments can be behavioural, physiological and anatomical
- Adaptation and selection are major factors in evolution and make a significant contribution to the diversity of living organisms

Article - Amazing Med-Tech of the Future

Joseph Langley, MEng, CEng MIMechE

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

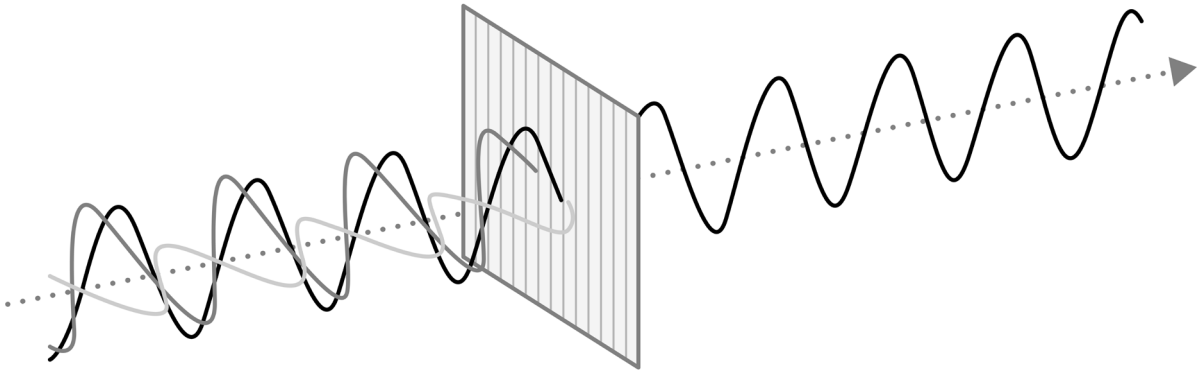
A3.1 The purpose of legislation and regulations in the health and science sector

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



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Learning notes

The world of Quantum Technologies

Linked Article: **The Peculiar Powers of Polarisation**

Alan Denton's article on The Peculiar Powers of Polarisation is a great starting point for taking your students on a journey through the science behind and applications of a range of quantum technologies. In support of STEM Learning's Quantum Ambassador Programme, a range of self-guided, interactive learning modules have been designed to take students through not only polarisation, but a range of exciting technologies and phenomena.

Learning Task:

Head to the Quantum Technologies Programme online learning modules here: www.stem.org.uk/quantum

The first of the four modules – Quantum Communications builds upon the science and technology discussed in The Peculiar Powers of Polarisation and will challenge the understanding of your students.

Divided into four sub-modules, students will explore why we need cryptography, what underlying physics do they need to understand and where quantum physics fits in to all of that!

The module will take approximately 40 minutes to 1 hour for students to complete and includes questions and interactive tasks throughout.

Take your learning further:

After exploring the Quantum Communications module students can develop their understanding of the many applications of quantum technologies by exploring the remaining 3 modules. All modules are supported with curricula links and include opportunities for students to test their understanding.

Each module will take approximately 40 minutes to 1 hour for students to complete.

Take your learning further still:

The Quantum Ambassador Programme supports post-16 teachers and students in their teaching and learning of quantum technologies and the underlying physics by bringing scientists and professionals that use quantum technologies into the classroom. Ambassadors will bring the material in the online modules to life by sharing insights into their career and daily work.

You can sign up to the programme by visiting the Quantum Ambassador Programme webpage here: www.stem.org.uk/quantum-ambassador-programme

Learning notes

Bearings in the real-world

Linked Article: **Maths in a Cold climate**

The Maths in a Cold climate article explores life as a Land Surveyor - in particular measuring parts of the Antarctic peninsula.

To know where they were on the ice, and to find the exact spot where the depots of food and supplies were- with very few recognisable landmarks – the Antarctic explorers used bearings.

There are many professions that require knowledge and use of bearings for navigation. The resources below allow students to explore some of them.

Learning Task:

You may wish to use the MEP's Angles, Bearings and Maps resources first if your students haven't seen bearings before.

Mysteries of the deep Earth resource is a series of lessons that ask students to complete a variety of tasks based on real-life situations to support a scientific research vessel on its journey exploring another extreme climate- submerged volcanoes.

In the first lesson covering bearings, students are asked to imagine that they are a modern day scientist about to embark on a journey on board the research vessel:

"You are the navigator on the voyage. The scientists have told you a number of key sites where they want to collect data and have marked them on the map.

Calculate the bearings and distances that you will have travel on at each point in voyage so you can tell the captain where to sail. The voyage will set sail from Cairns and finish in Brisbane."

The objective of this lesson is for students to apply their knowledge of bearings to a real-world navigation scenario. Students will be required to measure bearings and, if they reach the extension activity, construct bearings.

The complete collection- including presentations and student worksheets- can be found here. Topics covered include coordinates, estimation, conversion of units and negative numbers.

Take your learning further:

The bearings resources from Defence Dynamics students work as the Operations Team for a Royal Air Force (RAF) squadron on Quick Reaction Alert (QRA).

Presented with a series of imaginary scenarios, students have to review and plan routes for a number of aircraft facing different crises.

The lesson aims to help the development of a range of different skills such as varying scale maps, distances, bearings and aircraft speeds.

Take your learning further still:

Further bearings practice can be found in this resource from the Royal Observatory Greenwich, in which students use bearings to plot constellations.

To find out more:

More bearings lesson can be found in our Measuring Lines, Angles and using Scale drawings collection.

Learning notes

Rockets: physics and chemistry in action

Linked Article: **It's Not Rocket Science, Or Is It?**

Launching rockets brings together the chemistry of combustion and the physics of Newton's Laws. The author shows how with the combustion of a fuel and an oxidiser, the exhaust gases provide the thrust to accelerate the rocket and its payload in the opposite direction.

Learning Task:

This experiment must be performed in the laboratory with the supervision of a science teacher or technician. You will be launching your own ethanol fuelled rocket in the lab.

You will need:

- An empty (and dry) drinks bottle with sports cap
- Ethanol or isopropanol
- A section of guttering or similar
- Safety glasses
- Long matches or similar
- A beaker

1. Put on your safety glasses.
2. Pour 10ml of the alcohol into the drinks bottle, close the lid and shake for one minute. The idea is to produce a vapour within the bottle.
3. Pour off the excess liquid into the beaker, and close the lid again.
4. Place the bottle into the guttering and point away from people and fragile objects. Ideally, give as much room as possible for the rocket to travel.
5. Pull open the sports cap, light a match and hold it to the hole in the cap.

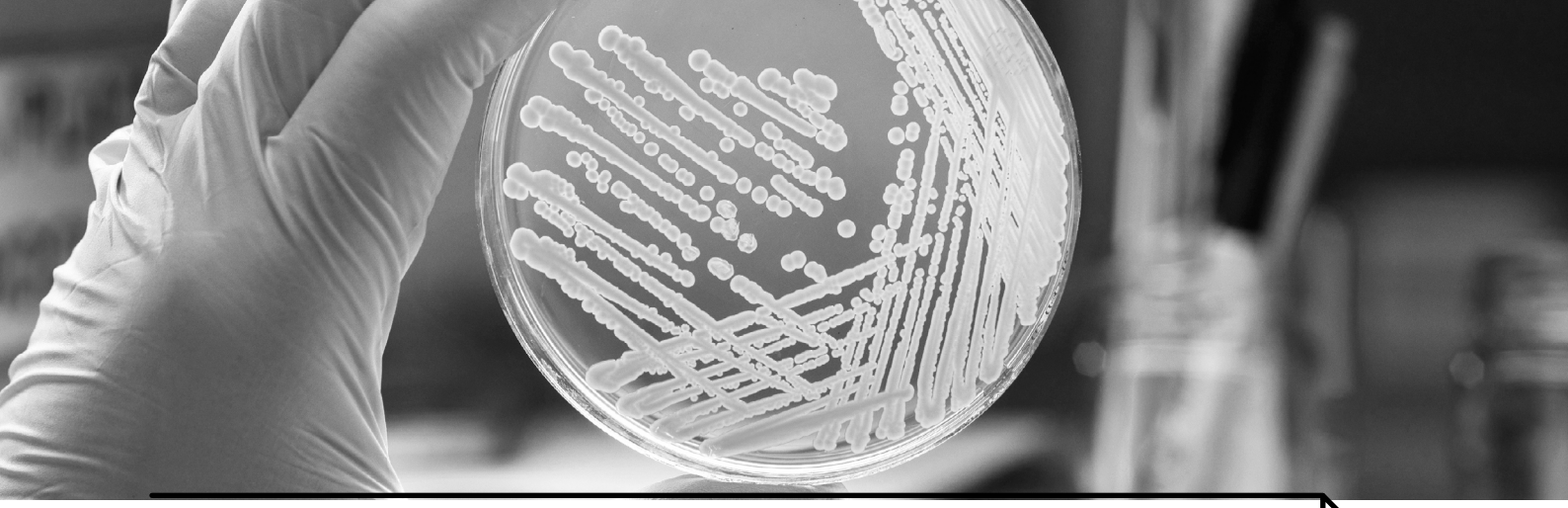
Health and safety - please seek advice from SSERC or CLEAPSS.

Take your learning further:

Investigate the chemistry of the reaction with this learning resource.

Take your learning further still:

Place a force meter connected to a datalogger at the base of the bottle to measure the force vs. time for the rocket, and calculate the impulse. You will need to place a clamp or similar loosely around the neck of the bottle to ensure it does not flip when lit.



4

Learning notes

What are prokaryotes and how do we count them?

Plus - using Cornell note making or other note making techniques to get more from reading an article.
Linked Articles: **Investigating the sleeping state in bacteria**

This article is wide ranging and has quite a bit of information to make sense of, so you may want to use a note making technique to support your reading of it. There is a link in the learning tasks to two videos introducing a method of making notes, called the Cornell notes system that you may like to try out as a way to focus your reading.

If this article has captured your imagination and you would like to know more about the fascinating world of bacteria and what microbiologists study, there is a menu of suggested wider reading below. The first two learning tasks link directly to content often found on post-16 biology specifications and the later ones to wider reading.

Learning Task:

As you read the original Catalyst article or one or more of the suggestions below you may want to focus your reading by making notes. Your notes could be in the form of a mini mind map, Cornell notes, a bullet point list, questions that the article makes you ask yourself or another method of your choice. Watch the videos to learn about making Cornell notes –here

Support your understanding of what bacterial cell are and post-16 biology specification subject content clicking the 'Introduction of prokaryotic cell' link here.

Support your understanding of how we count cells by trying out this Virtual Haemocytometer and then comparing the method used in the virtual lab with the method Dr Sariqa Wagley describes in the article and used in her research.

Take your learning further:

The Catalyst article, on the sleeping state of bacteria, talks about the features and properties that bacteria have leading to them causing disease in humans. Bacteria can't deliberately make humans ill – evolution has resulted in them being adapted to survive inside the human body. You can read more about the evolution of pathogenic bacteria and their means of survival in the human body in 'Pathogenic bacteria: wolves in sheep's clothing,' Christoph M. Tang.

You can read about bacteria in the human gut and how they survive in this article, 'Gut microbes: we are not alone,' by Nathalie Rolhion.

Take your learning further still:

This article talks about bacterial proteins and the specialised microscopy used to study them, 'Using mighty microscopes to look at microbial machinery,' by Rachel Harding.

Learning notes

Discovering Careers

This edition of Catalyst introduces you to a variety of STEM subject topics and the careers and roles of the authors, helping to open the world of potential STEM led careers you could do. A key aspect of this edition is understanding the role that maths can play in future careers, it doesn't stop being used in school, it plays a fundamental role in every person's daily life, let alone those who seek a career that uses it.

Whether surveying antarctica, working on highly complex engineering systems or looking to launch a rocket the maths involved is obvious. However, analysing science data for dormant bacteria or preparing a science report on your latest research project still uses maths. Maths has a role to play in many jobs both large and small.

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.

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 how maths is used in in a variety of different careers, jobs and roles.

- Research a career you are interested in and identify how it uses maths and what level of maths you need, GCSE, A 'Level, degree?
- Create a list of jobs and careers that use maths and identify how they use it, then create a list of jobs that use no maths, compare and discuss with family and friends.
- Ask your teacher or STEM Club leader if they could arrange for a STEM Ambassador to visit and give a talk about their work and how they use maths.
- Discuss with family and friends about their jobs and how they use maths both at work and in daily life
- Think about how you use maths in your daily life, do you use it more or less than you thought?

Skill sets

We are asked some of the authors to think about key or essential skills they need for their work, consider their skills and think through your own skill set. Identify three you think you should enhance to help you with your potential career.

- Amitkumar: Communication, problem solving, teamwork, creativity
- Daniel: Problem solving, teamwork, project management, aiming high
- Jessica: Problem solving, resilience, project management, written and spoken communication, time management, ability to work well in a team, open to criticism
- Joseph: Engineering, biology & chemistry knowledge, communication, problem solving, resilience

You can help improve essential employability skills, the Skills Builder Universal Framework is a free tool you can use: www.skillsbuilder.org/about-launchpad. Use it to assess your skills and to help improve them.

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 rocket science:

- spacecareers.uk/?p=job_profiles
- www.nasa.gov/audience/foreducators/rocketry/careercorner/index.html#.YlPqzNPMKUk
- www.chemistryworld.com/careers/not-exactly-rocket-science/5020.article

Careers in science research:

nationalcareers.service.gov.uk/job-categories/science-and-research

www.prospects.ac.uk/job-profiles/research-scientist-life-sciences

www.pearson.com/uk/learners/fe-and-college-students/career-choices/science-technology-and-it/science-and-research.html

Careers that use maths:

www.mathscareers.org.uk

targetcareers.co.uk/uni/degree-subject-guides/313825-mathematics-degrees-what-you-ll-study-and-your-career-options

www.bbc.co.uk/bitesize/tags/zrsg6v4/jobs-that-use-maths/1

www.careerpilot.org.uk/job-sectors/subject/maths

National Careers Service: nationalcareers.service.gov.uk

STEM Learning: www.stem.org.uk/stem-careers

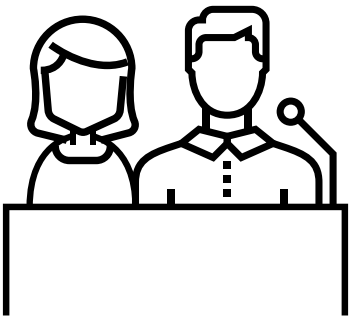
Meet our authors and 1000's of inspiring STEM role models like them!

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:

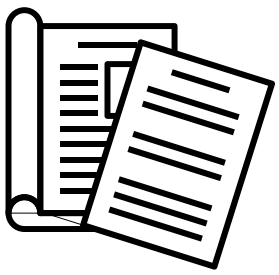
- provide an online talk for your class
- judge a STEM competition in your school or college
- attend a parents evening and talk about careers linked to STEM subjects
- run a practical activity for a STEM subject club



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**)
- 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**



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

Join us on Twitter **@STEMLearningUK**

Visit our website **www.stem.org.uk/catalyst**