STE(A)M IT

AN INTERDISCIPLINARY STEM APPROACH

STEM CAREERS IN THE CLASSROOM (AND BEYOND)

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SPEAKERS

Dr Stacey Habergham-Mawson

Manager, National Schools' Observatory

Erica Morgan

Assistant Editor, Futurum Careers

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Inspiring the next generation

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WHO AM I?

- Astrophysicist and science communicator
- Manager of the National Schools' Observatory
- Lecturer at Liverpool John Moores University and the University of Liverpool

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HOW DID I GET HERE?

FROM SCHOOL TO ASTROPHYSICS TO PROJECT MANAGEMENT AND SCIENCE COMMUNICATION

INTERESTS AND INSPIRATION

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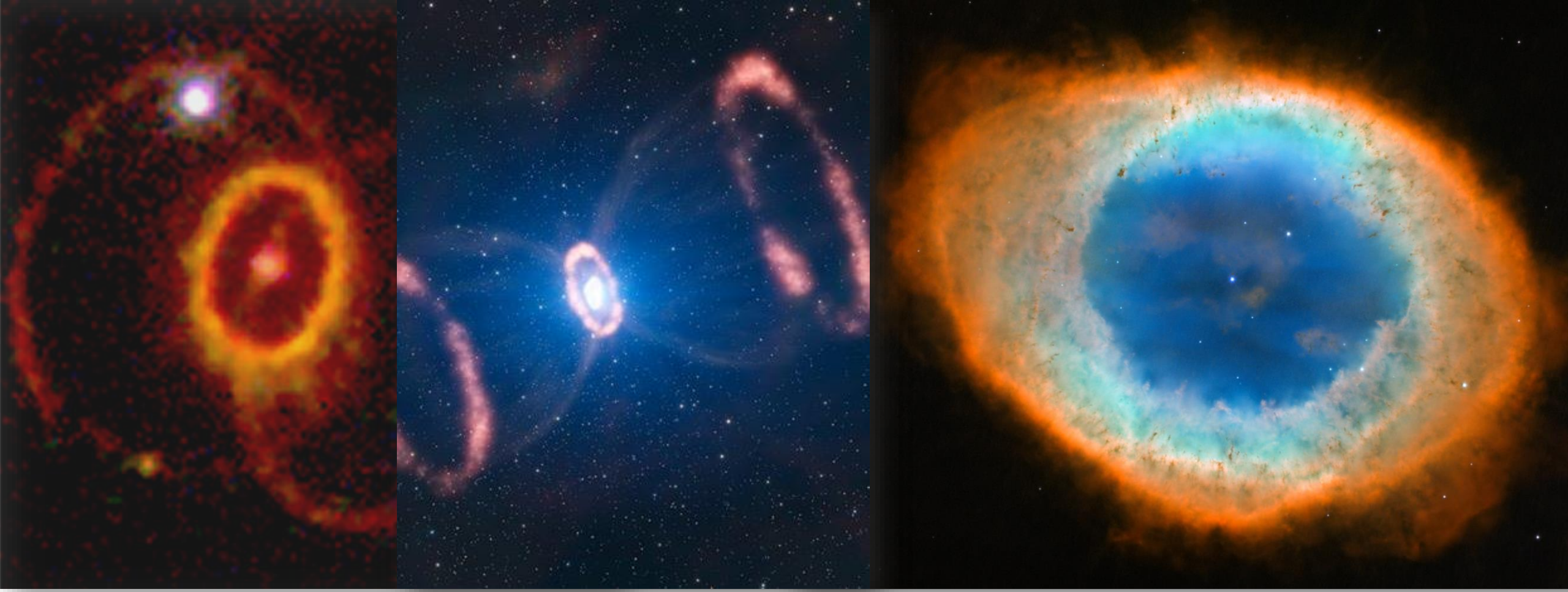

INSPIRATION

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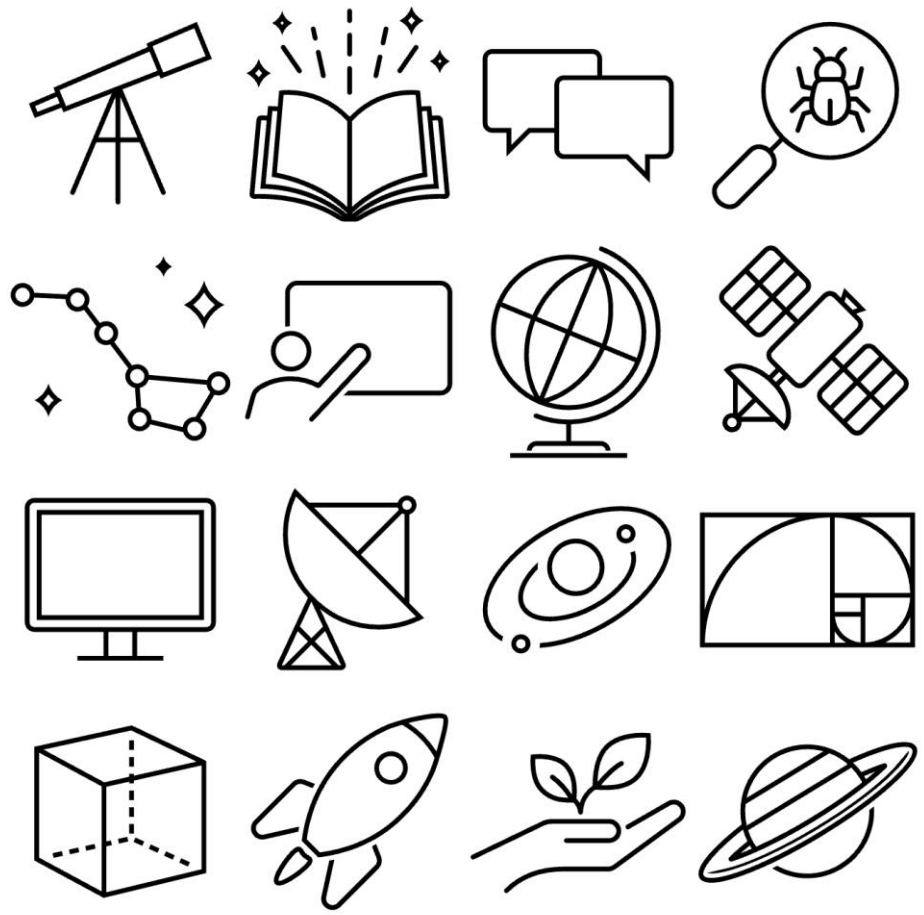
CAREERS

Interests:

- Computers
- Explaining
- Exploring
- History
- Influencing
- Making things
- Nature
- Numbers
- Space Travel
- Stargazing



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Jarita Holbrook
Credit: AAAS portrait photographer.
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Jarita Holbrook

Degree: PhD in Astrophysics

Now: History and Cultural Studies of Astronomy

"There is a history of sky-watching all over the world, but they way that we teach astronomy is only Newton and Galileo and perhaps Stonehenge."

Adriana Ocampo
Credit: NASA/Aubrey Gemignani

Adriana Ocampo

Degree: PhD in Geophysics

Now: Planetary science and meteorite craters

"When thinking about the great adventure that you have ahead, dream and never give up, be persistent and always be true to your heart."

Kevin Govender
Credit: IAU/Kevin Govender
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Kevin Govender

Degree: Physics

Now: Astronomy for Development

"I see every day how people who are moved by our place in the Universe are inspired to move others."

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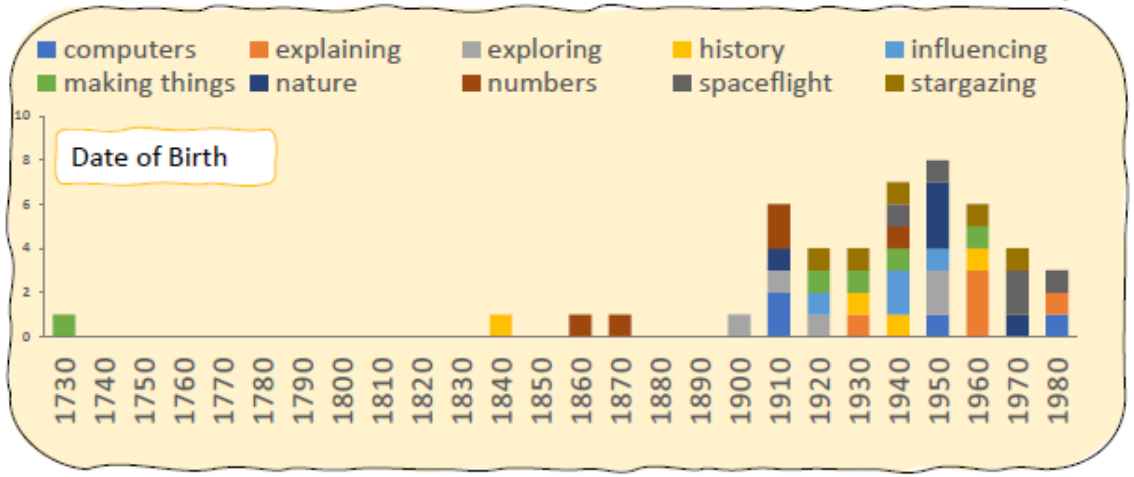
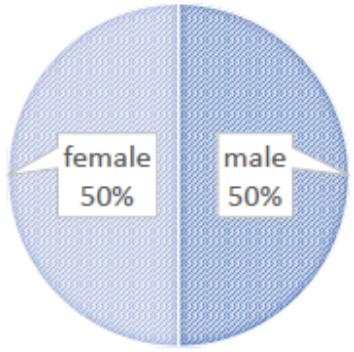
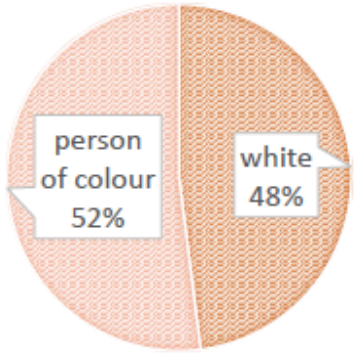
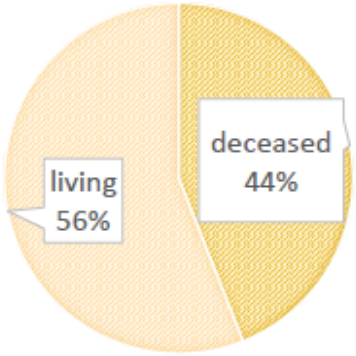
THE IMPORTANCE OF DIVERSITY….

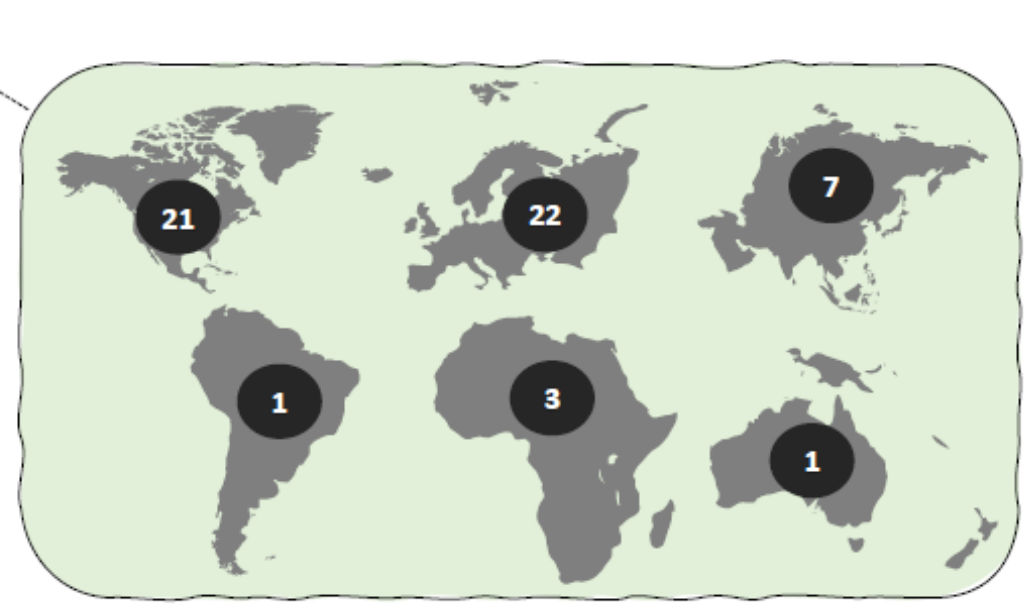
NSO Careers











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THE NATIONAL SCHOOLS' OBSERVATORY

Access to the Universe for All

WWW.SCHOOLSOBSERVATORY.ORG

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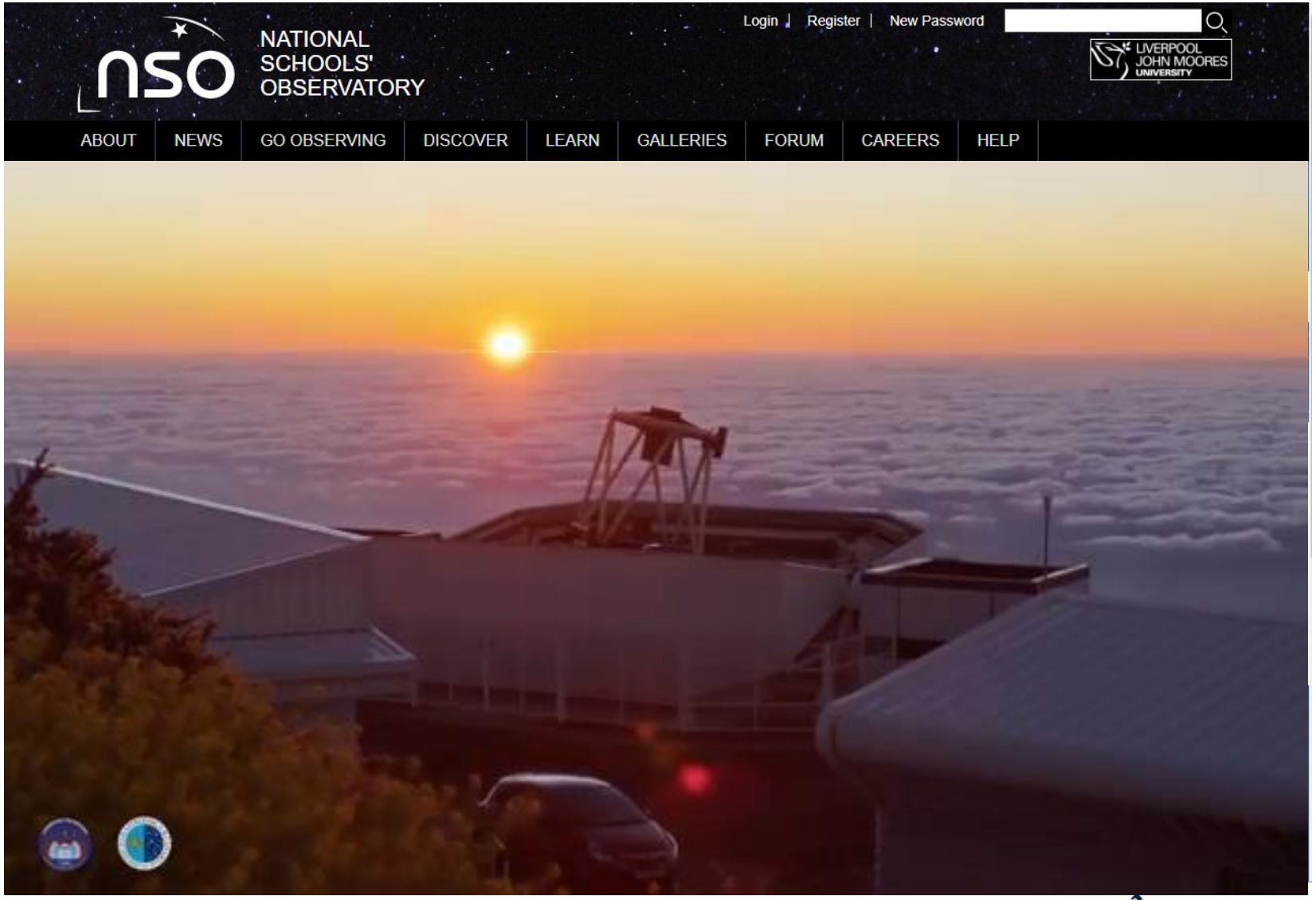
WEBSITE

- FREE access to the world's largest robotic telescope
- 10% of telescope time
- All schools across the UK and Ireland have enhanced access
- Anyone from around the world can have access as a 'user'



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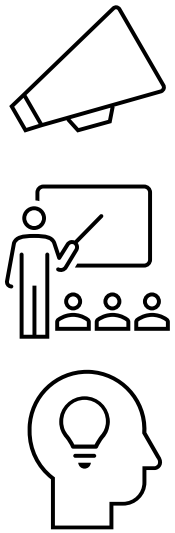
OUR ETHOS



"Tell me and I forget.
Teach me and I remember.
Involve me and I learn."

Benjamin Franklin

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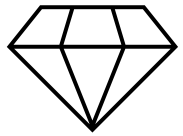
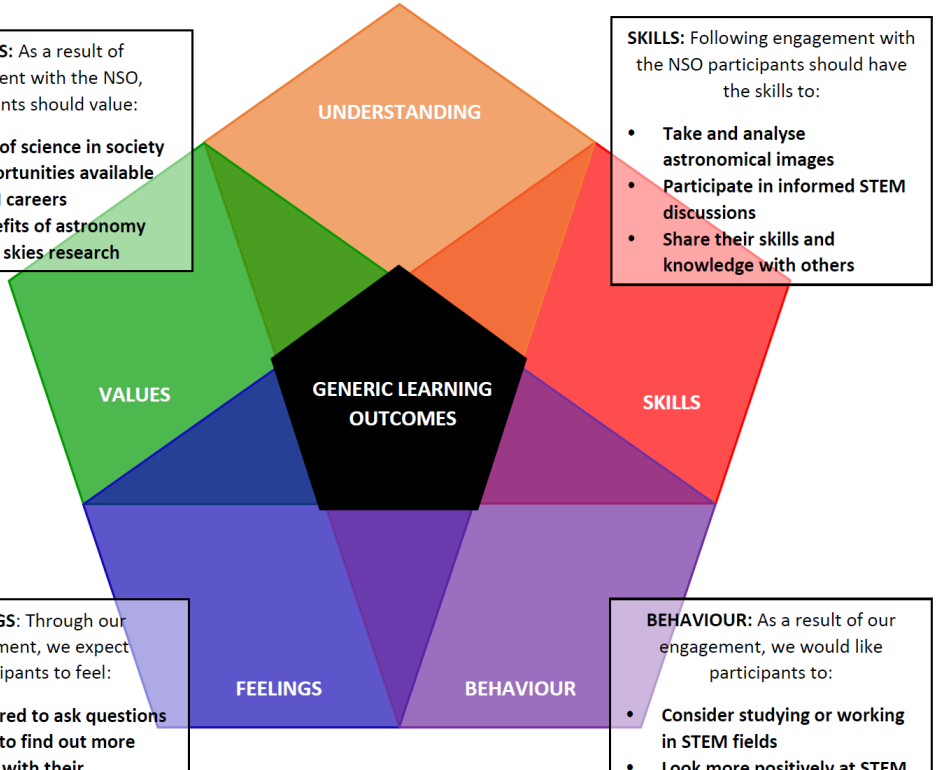
UNDERSTANDING: The specific **understanding** and **knowledge** transfer will vary with each activity we carry out, but they will be based around the theme of engaging young people in STEM through the draw of space and astronomy.



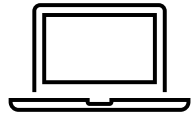
VALUES: As a result of engagement with the NSO, participants should value:

- **The role of science in society**
- **The opportunities available for STEM careers**
- **The benefits of astronomy and blue skies research**



SKILLS: Following engagement with the NSO participants should have the skills to:

- **Take and analyse astronomical images**
- **Participate in informed STEM discussions**
- **Share their skills and knowledge with others**

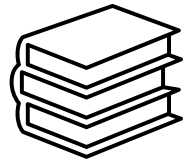


FEELINGS: Through our engagement, we expect participants to feel:

- **Empowered to ask questions**
- **Inspired to find out more**
- **Satisfied with their experience**

BEHAVIOUR: As a result of our engagement, we would like participants to:

- **Consider studying or working in STEM fields**
- **Look more positively at STEM**
- **Participate in more STEM activities**



GENERIC LEARNING OUTCOMES

More than just knowledge…

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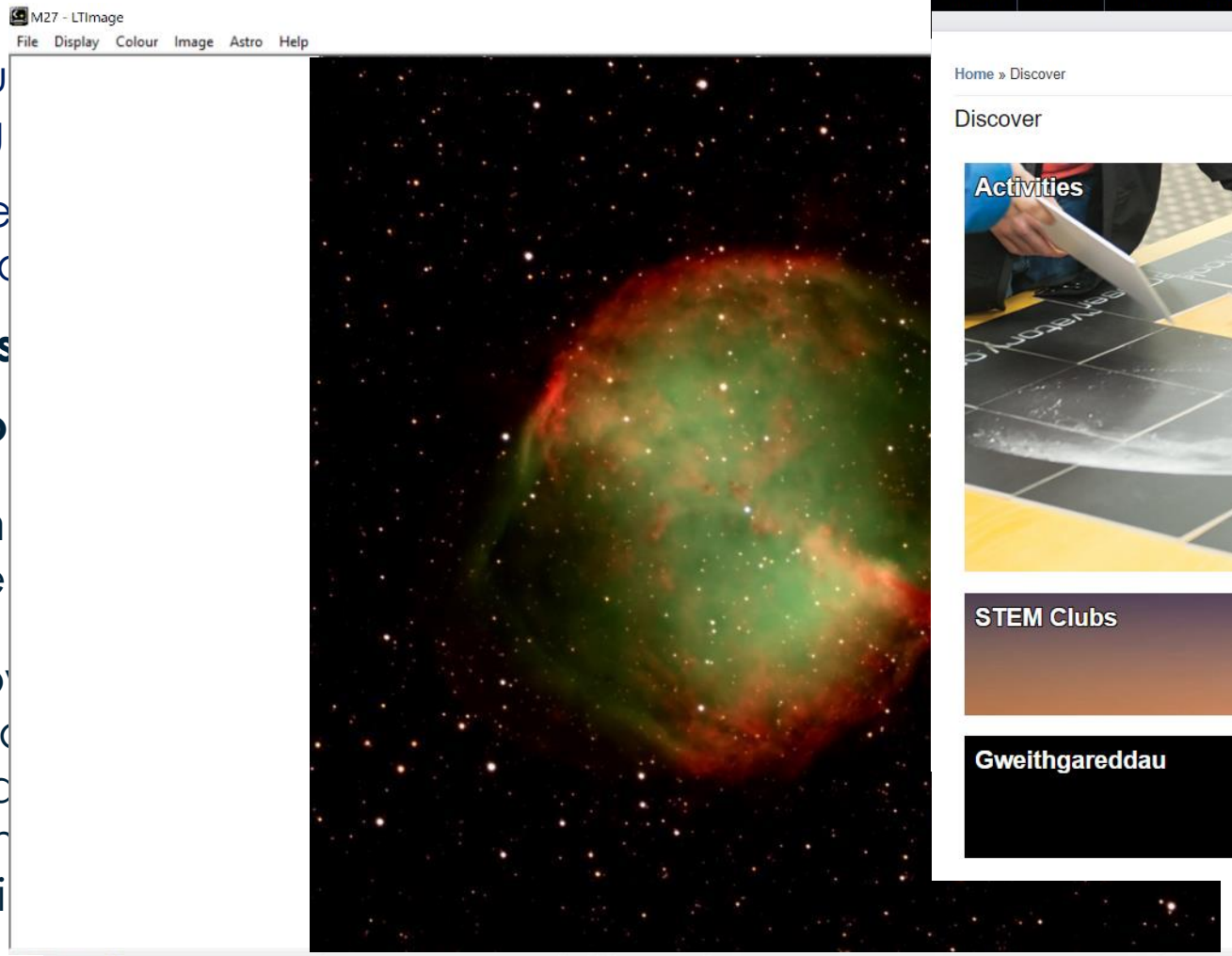

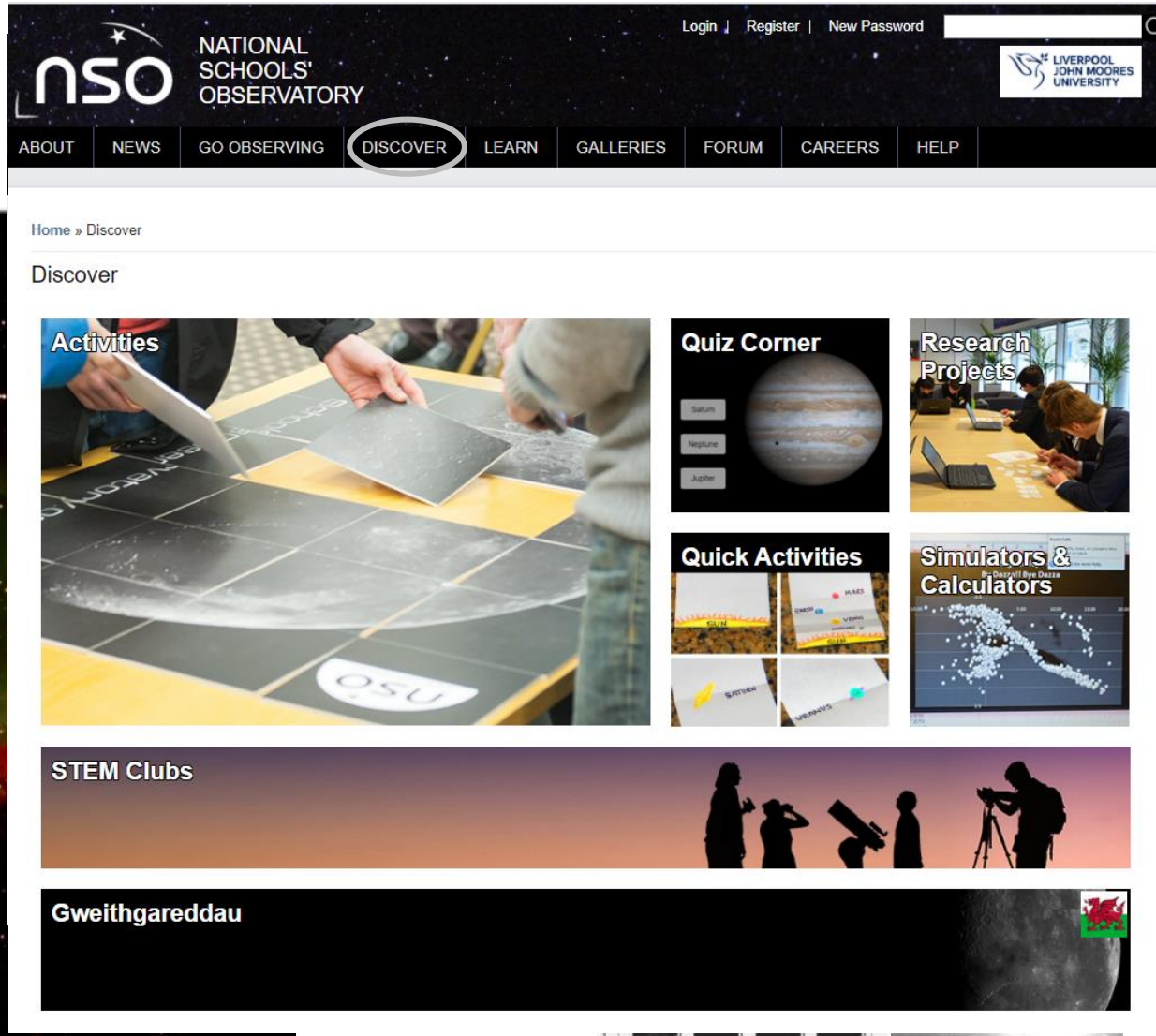

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CLASSROOM ACTIVITIES

NATIONAL SCHOOLS' OBSERVATORY - DISCOVER

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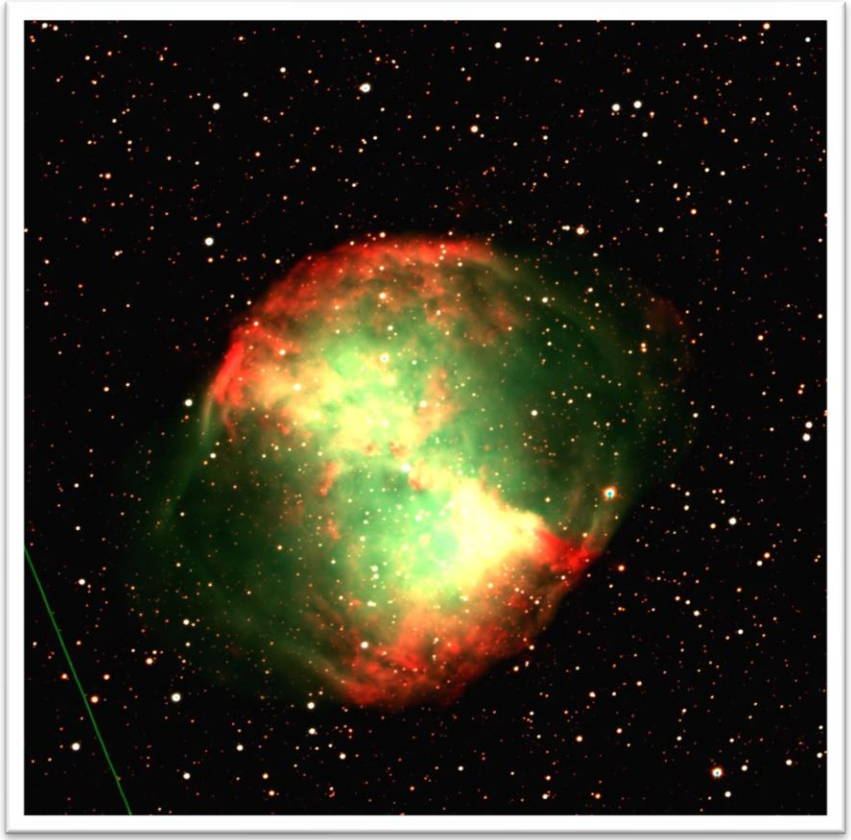
ACTIVITIES

- Suitable for ages 5 - 18
- Currently:
  - 13 quick activities;
  - 24 classroom lesson activity packs;
  - 6 in-depth research projects;
  - 19 STEM club activities
- **Science** topics covered include **technology**, light, gravity, orbits, tides, observing, Solar System, stars, cosmology
- **Skills** – computing, numeracy, processing data, problem solving, trial and error, evaluating results
- Opportunities for acquiring and applying knowledge of new **computing software**



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ACTIVITY: SPACE JOBS

- Pupils investigate the jobs available to those who enjoy space and science through games, quizzes and discussion.
- Space Jobs Quiz
- Sta

Statement	Supporting info /Discussion Points	NSO Career Profile
Girls and boys can go to space **Answer - TRUE**	Can you think of any women astronauts? More than 50 women have travelled to space. The First woman in space was Valentina Tereshkova – a Soviet cosmonaut who flew in 1963. Helen Sharman was the first British women to go to space in 1991. This is why we use the word "astronaut" rather than "spaceman".	Mae Jemison (Spaceflight)
All scientists are boys **Answer - FALSE**	Every section of the NSO careers pages showcase male and female scientists.	Beatrice Tinsley (Stargazing)
Most of the first computer programmers were girls **Answer - TRUE**	A computer programmer writes code for computer programs. The first programmers were mainly women and women contributed significantly to the industry.	Dorothy Vaughn (Computers)
Girls are better at writing than boys **Answer - FALSE**	Who are your favourite authors? Many books have been written by men and women about the history of stargazing and space exploration.	Anthony Aveni (History)

- Discussion
- Stereotypes
- Careers
- Skills
- Interests
- Self-discovery

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INTERDISCIPLINARY APPROACH

- NSO is guided by the principle of '**doing**' science
- Space/Astronomy is the **hook** to engage students with STEM more broadly
- The website is a huge, **free** resource, which includes access to the worlds largest robotic telescope
- **Packaged** classroom activities include (all) science, maths, computing, technology, literacy – these will only expand in the coming year
- More **cross-curricular** activities through our STEM club section – due to be expanded and revamped in the next 3 months

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FUTURUM CAREERS

INSPIRING THE NEXT GENERATION

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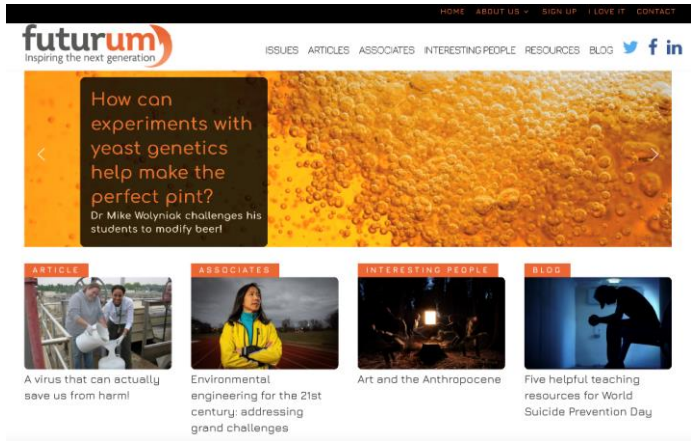
FUTURUM CAREERS

- A **free teaching resource** for use in schools and at home
- We work with **academics** to create **STEAMM teaching resources** aimed at **14-19-years-olds**
- **Free to download** from our website, Scientix, TES, Teachers Pay Teachers and the European Geosciences Union
- A **career guidance** tool that follows Gatsby Benchmarks



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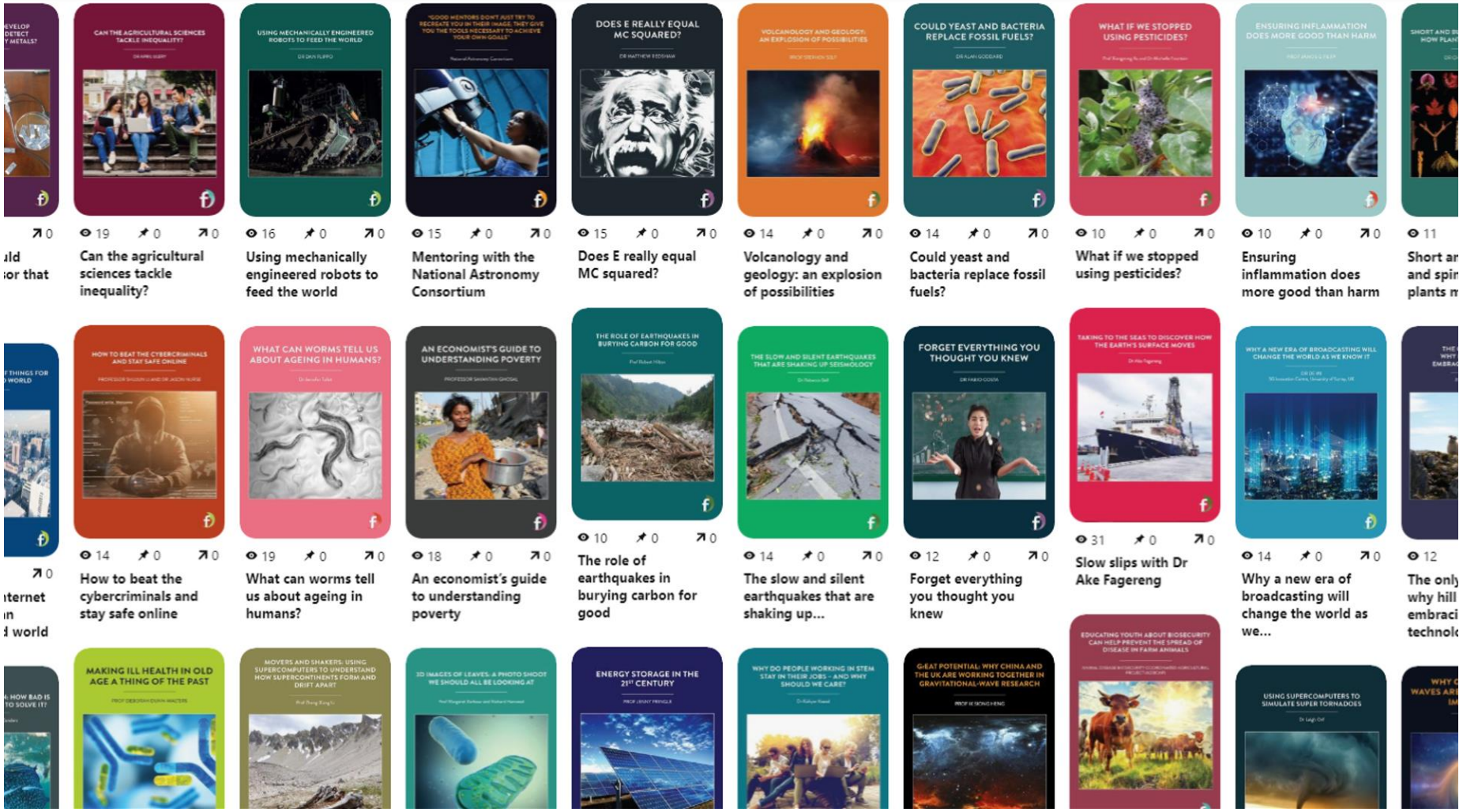

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Can the agricultural sciences tackle inequality?

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Using mechanically engineered robots to feed the world

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Mentoring with the National Astronomy Consortium

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Does E really equal MC squared?

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Volcanology and geology: an explosion of possibilities

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Could yeast and bacteria replace fossil fuels?

10 0 0
What if we stopped using pesticides?

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Ensuring inflammation does more good than harm

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How to beat the cybercriminals and stay safe online

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What can worms tell us about ageing in humans?

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An economist's guide to understanding poverty

10 0 0
The role of earthquakes in burying carbon for good

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The slow and silent earthquakes that are shaking up...

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Forget everything you thought you knew

31 0 0
Slow slips with Dr Ake Fagereng

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Why a new era of broadcasting will change the world as we...

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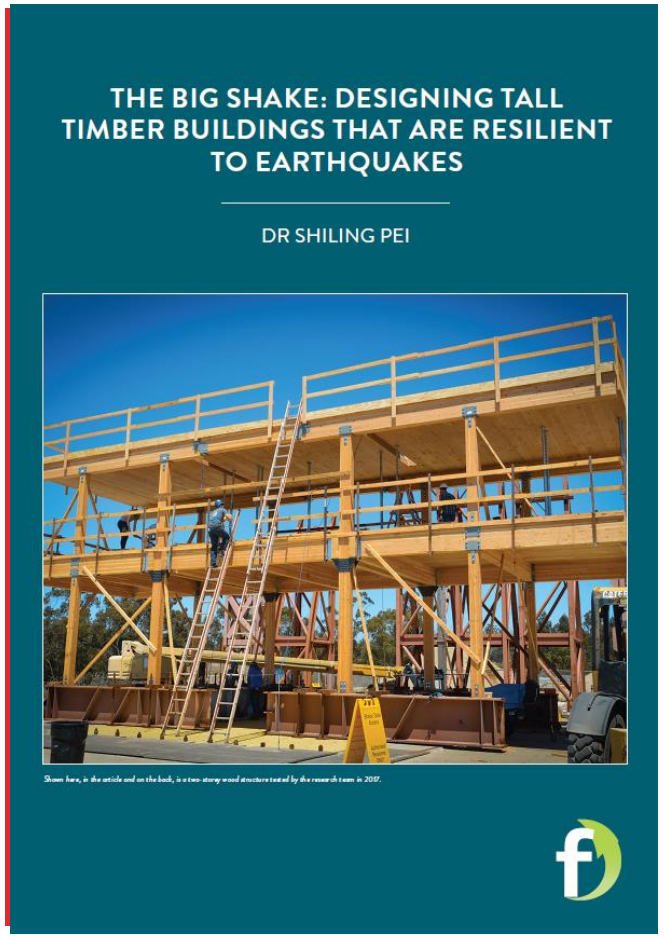
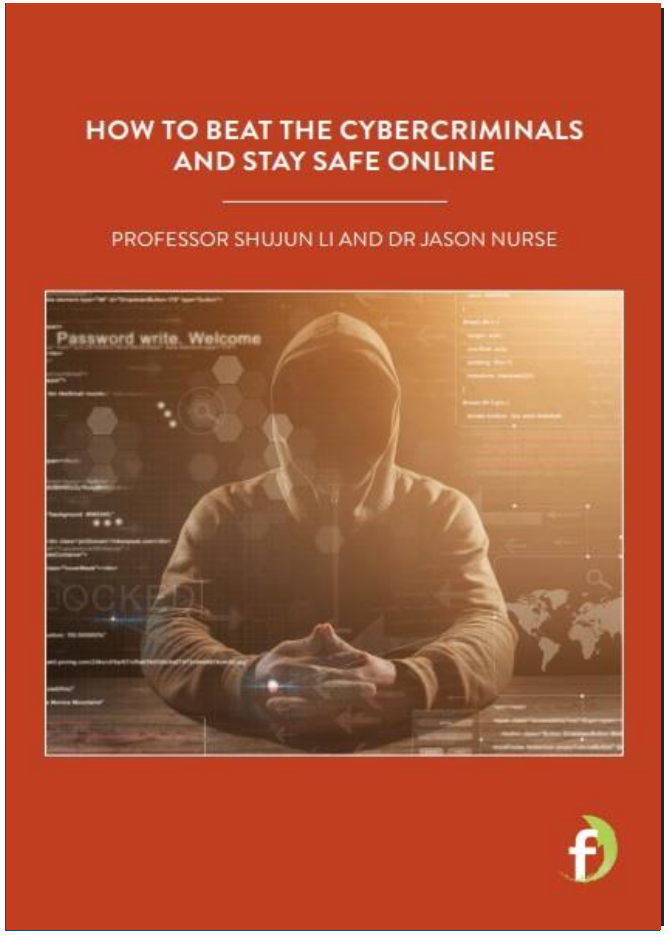
See a breadth of **opportunity**





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Learn about **real-life applications**

WHAT IF WE COULD DEVELOP A SENSOR THAT CAN DETECT POLLUTANTS LIKE HEAVY METALS?

DR HELEN BRIDLE IS AN ASSOCIATE PROFESSOR AT **HERIOT-WATT UNIVERSITY** IN THE UK. ONE OF HER CURRENT RESEARCH PROJECTS IS FOCUSED ON DEVELOPING NOVEL SENSORS TO EXPLORE THE RELATIONSHIP BETWEEN ANTIMICROBIAL RESISTANCE AND POLLUTANTS IN INDIA

Antimicrobial resistance (AMR) is when microorganisms, such as bacteria, fungi, parasites and viruses, evolve ways to survive treatments, including antibiotic, antiviral and antifungal medicines. The World Health Organisation considers AMR to be an 'increasingly serious threat to global public health that requires action across all government sectors and society' and estimates that an additional $1.2 trillion will be spent on health every year by 2050 because of AMR.

Clearly, AMR is a significant issue that needs to be better understood so that researchers can find solutions in the near future. Dr Helen Bridle is based at Heriot-Watt University in the UK and is conducting research to explore the relationship between AMR and pollutants. One of the areas of her team's focus is in India, which has one of the highest per capita use of antibiotics in the world.

WHY DOES INDIA RELY SO HEAVILY ON ANTIBIOTICS COMPARED TO OTHER COUNTRIES IN THE WORLD?

The more we use antibiotics, the more opportunities bacteria have to develop resistance. If people are not aware of this, they are unlikely to change their behaviour. A lack of understanding is one of the major factors behind increased incidence of AMR. "One of the main problems in India is the cheap unregulated access to antibiotics, e.g. over-the-counter sales with a prescription, which means that there is little control over whether antibiotics are used appropriately or at the correct dose," explains Helen. "Other problems arise in the healthcare system, such as doctors receiving compensation for antibiotic prescriptions and relatively high levels of healthcare associated infection, which also contributes to the heavy usage of antibiotics in India."

WHAT ARE HELEN AND HER TEAM HOPING TO UNDERSTAND IN THEIR RESEARCH?

It is known that water – particularly wastewater – plays a significant role in the spread and transfer of AMR, although there have been relatively few studies in this area to date. Helen's research is designed to explore the relationship between AMR and pollutants, specifically heavy metals and additives such as triclosan (which is used in soap and toothpaste). Because these heavy metals and additives are also harmful to bacteria, they develop resistance mechanisms to them, which appear to bolster their resistance to antimicrobial treatments. Helen hopes to understand more about how these mechanisms work in the environment so that solutions can be found.

HOW ARE THE TEAM DETECTING AND MONITORING POLLUTANTS IN THE WATER?

The team is using novel sensor technologies to use in the field and explore the relationship between AMR and pollutants. These sensors will further our understanding in several ways. "Low-cost easy-to-use sensors will enable a greater degree of monitoring and detailed case studies to understand how the presence of co-selectors of resistance, such as pollutants like heavy metals and additives, impact on antibiotic resistance in the water environment," says Helen. "Once we have improved our understanding of these subjects, it will enable policymakers and water companies to design effective interventions."

HOW WILL THE SENSORS WORK?

The sensors that the team at Heriot-Watt University are developing will target the AMR genes in a water sample. In order to do this, the system needs to extract DNA from bacteria found in the water and then identify the specific sequences that are known to be associated with AMR. "We place recognition molecules on the sensor surface and when they are exposed to DNA, binding takes place," explains Helen. "We can then measure the binding that enables us to check water quality without the need to access specialised lab facilities."

It is hoped that the technology could one day be used by pollution control boards in India and around the world.

WHEN WILL THE SENSORS BE READY TO BE USED IN THE FIELD?

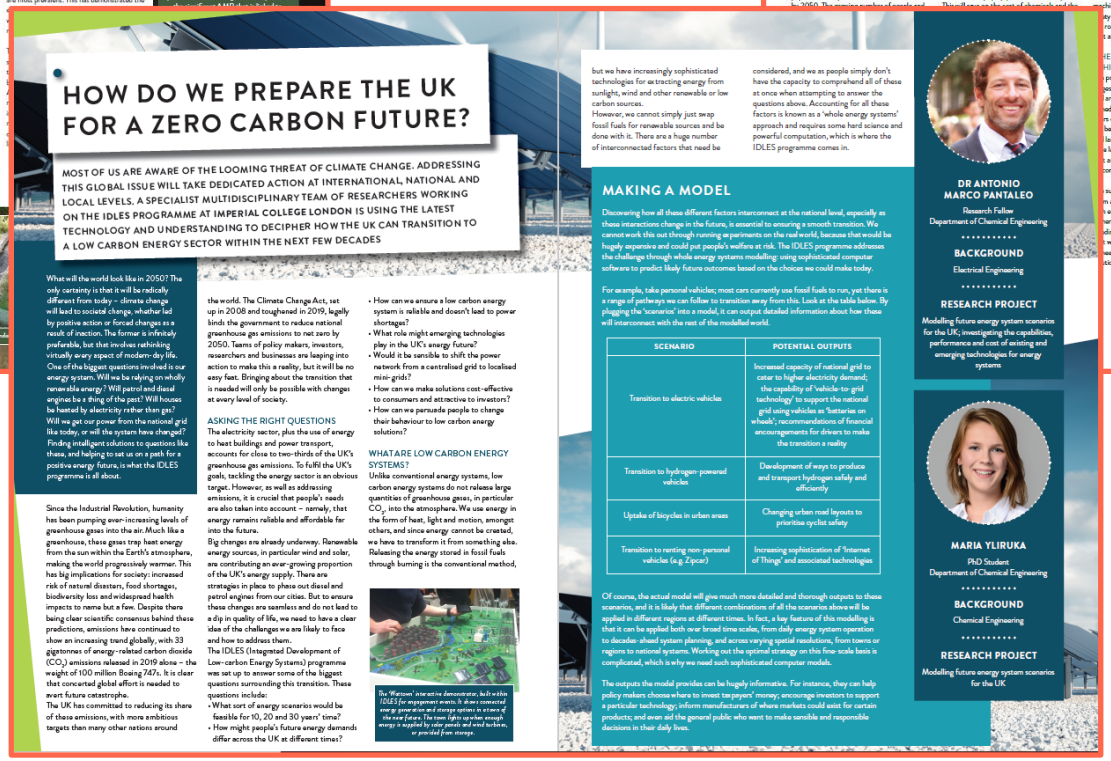
The project is already well underway and Helen's colleagues in India have started regularly monitoring different sites. They have identified which pollutants are typically found in different locations and the AMR genes that are most prevalent. This has demonstrated the

One of the sampling points in India

DR HELEN BRIDLE
Associate Professor, School of Engineering and Physical Sciences, Heriot-Watt University, UK

FIELD OF RESEARCH
Engineering and Physical Sciences

RESEARCH PROJECT
Helen's work is concerned with developing novel sensor technologies to explore the relationship between antimicrobial resistance (AMR) and pollutants. The findings could help tackle



HOW DO WE PREPARE THE UK FOR A ZERO CARBON FUTURE?

MOST OF US ARE AWARE OF THE LOOMING THREAT OF CLIMATE CHANGE. ADDRESSING THIS GLOBAL ISSUE WILL TAKE DEDICATED ACTION AT INTERNATIONAL, NATIONAL AND LOCAL LEVELS. A SPECIALIST MULTIDISCIPLINARY TEAM OF RESEARCHERS WORKING ON THE IDLES PROGRAMME AT IMPERIAL COLLEGE LONDON IS USING THE LATEST TECHNOLOGY AND UNDERSTANDING TO DECIPHER HOW THE UK CAN TRANSITION TO A LOW CARBON ENERGY SECTOR WITHIN THE NEXT FEW DECADES

What will the world look like in 2050? The only certainty is that it will be radically different from today – climate change will lead to societal change, whether led by positive action or forced changes as a result of inaction. The former is infinitely preferable, but that involves rethinking virtually every aspect of modern-day life. One of the biggest questions involved is our energy system. Will we be relying on wholly renewable energy? Will petrol and diesel engines be a thing of the past? Will houses be heated by electricity rather than gas? Will we get our power from the national grid like today, or will the system have changed? Finding intelligent solutions to questions like these, and helping to set us on a path for a positive energy future, is what the IDLES programme is all about.

Since the Industrial Revolution, humanity has been pumping ever-increasing levels of greenhouse gases into the air. Much like a greenhouse, these gases trap heat energy from the sun within the Earth's atmosphere, making the world progressively warmer. This has big implications for society: increased risk of natural disasters, food shortages, biodiversity loss and widespread health impacts to name but a few. Despite there being clear scientific consensus behind these predictions, emissions have continued to show an increasing trend globally, with 33 gigatonnes of energy-related carbon dioxide (CO_2) emissions released in 2019 alone – the weight of 100 million Boeing 747s. It is clear that concerted global effort is needed to avert future catastrophe.

The UK has committed to reducing its share of these emissions, with more ambitious targets than many other nations around the world. The Climate Change Act, set up in 2008 and toughened in 2019, legally binds the government to reduce national greenhouse gas emissions to net zero by 2050. Teams of policy makers, investors, researchers and businesses are leaping into action to make this a reality, but it will be no easy feat. Bringing about the transition that is needed will only be possible with changes at every level of society.

ASKING THE RIGHT QUESTIONS

The electricity sector, plus the use of energy to heat buildings and power transport, accounts for close to two-thirds of the UK's greenhouse gas emissions. To fulfil the UK's goals, tackling the energy sector is an obvious target. However, as well as addressing emissions, it is crucial that people's needs are also taken into account – namely, that energy remains reliable and affordable far into the future.

Big changes are already underway. Renewable energy sources, in particular wind and solar, are contributing an ever-growing proportion of the UK's energy supply. There are strategies in place to phase out diesel and petrol engines from our cities. But to ensure these changes are seamless and do not lead to a dip in quality of life, we need to have a clear idea of the challenges we are likely to face and how to address them.

The IDLES (Integrated Development of Low-carbon Energy Systems) programme was set up to answer some of the biggest questions surrounding this transition. These questions include:

- What sort of energy scenarios would be feasible for 10, 20 and 30 years' time?
- How might people's future energy demands differ across the UK at different times?
- How can we ensure a low carbon energy system is reliable and doesn't lead to power shortages?
- What role might emerging technologies play in the UK's energy future?
- Would it be sensible to shift the power network from a centralised grid to localised mini-grids?
- How can we make solutions cost-effective to consumers and attractive to investors?
- How can we persuade people to change their behaviour to low carbon energy solutions?

WHAT ARE LOW CARBON ENERGY SYSTEMS?

Unlike conventional energy systems, low carbon energy systems do not release large quantities of greenhouse gases, in particular CO_2, into the atmosphere. We use energy in the form of heat, light and motion, amongst others, and since energy cannot be created, we have to transform it from something else. Releasing the energy stored in fossil fuels through burning is the conventional method, but we have increasingly sophisticated technologies for extracting energy from sunlight, wind and other renewable or low carbon sources.

However, we cannot simply just swap fossil fuels for renewable sources and be done with it. There are a huge number of interconnected factors that need be considered, and we as people simply don't have the capacity to comprehend all of these at once when attempting to answer the questions above. Accounting for all these factors is known as a 'whole energy systems' approach and requires some hard science and powerful computation, which is where the IDLES programme comes in.

The 'Wattown' interactive demonstrator, built within IDLES for engagement events. It shows connected energy generation and storage options in a town of the near future. The town lights up when enough energy is supplied by solar panels and wind turbines, or provided from storage.

MAKING A MODEL

Discovering how all these different factors interconnect at the national level, especially as those interactions change in the future, is essential to ensuring a smooth transition. We cannot work this out through running experiments on the real world, because that would be hugely expensive and could put people's welfare at risk. The IDLES programme addresses the challenge through whole energy systems modelling: using sophisticated computer software to predict likely future outcomes based on the choices we could make today.

For example, take personal vehicles; most cars currently use fossil fuels to run, yet there is a range of pathways we can follow to transition away from this. Look at the table below. By plugging the 'scenarios' into a model, it can output detailed information about how these will interconnect with the rest of the modelled world.

SCENARIO	POTENTIAL OUTPUTS
Transition to electric vehicles	Increased capacity of national grid to cater to higher electricity demand; the capability of 'vehicle-to-grid technology' to support the national grid using vehicles as "batteries on wheels"; recommendations of financial encouragements for drivers to make the transition a reality
Transition to hydrogen- powered vehicles	Development of ways to produce and transport hydrogen safely and efficiently
Uptake of bicycles in urban areas	Changing urban road layouts to prioritise cyclist safety
Transition to renting non-personal vehicles (e.g. Zipcar)	Increasing sophistication of 'Internet of Things' and associated technologies

Of course, the actual model will give much more detailed and thorough outputs to these scenarios, and it is likely that different combinations of all the scenarios above will be applied in different regions at different times. In fact, a key feature of this modelling is that it can be applied both over broad time scales, from daily energy system operation to decadal-ahead system planning, and across varying spatial resolutions, from towns or regions to national systems. Working out the optimal strategy on this fine-scale basis is complicated, which is why we need such sophisticated computer models.

The outputs the model provides can be hugely informative. For instance, they can help policy makers choose where to invest taxpayers' money; encourage investors to support a particular technology; inform manufacturers of where markets could exist for certain products; and even aid the general public who want to make sensible and responsible decisions in their daily lives.

DR ANTONIO MARCO PANTALEO
Research Fellow
Department of Chemical Engineering

BACKGROUND
Electrical Engineering

RESEARCH PROJECT
Modelling future energy system scenarios for the UK; investigating the capabilities, performance and cost of existing and emerging technologies for energy systems

MARIA YLIRUKA
PhD Student
Department of Chemical Engineering

BACKGROUND
Chemical Engineering

RESEARCH PROJECT
Modelling future energy system scenarios for the UK

USING MECHANICALLY ENGINEERED ROBOTS TO FEED THE WORLD

DR DAN FLIPPO IS AN ASSOCIATE PROFESSOR AT KANSAS STATE UNIVERSITY IN THE US. HIS LABORATORY, 2050RL, IS TRYING TO FIND TECHNOLOGICAL SOLUTIONS TO SUSTAINABLY FEED MORE THAN 9 BILLION PEOPLE BY 2050 AND BEYOND

According to the United Nations, the global population is expected to reach 9.8 billion by 2050. The growing number of people and

grain plant. If aphids are spotted, the scouting robots will only spray pesticides on that plant. This will save on the cost of chemicals and the

therefore designed a powered tiller that cuts a furrow in the soil to put seeds in. These machines are controlled by a computer, so ...ety is a major concern. Fortunately, because ...robots are so small, they are unlikely to ...anybody if they accidentally hit them.

...HEN WILL DAN'S ROBOTIC ...HICLES BE WORKING IN FIELDS?

...process has been designed to work in ...ps, so that everything can be fine-tuned ...any issues with safety and liability can be ...ed out. It is expected that in the next five ...rs or so, more and more scouting robots ...be deployed in fields, while the drones ...larger vehicles will start to be used a ...later than that. Ultimately, it is hoped ...autonomous, self-driving tractors will ...commonplace in fields around the world.

...sustainable approach that Dan and his ...m are taking means they are working ...h ecologists and environmental scientists, ...ar than being in competition with them. ...ding the world of the future is a problem ...will affect all of us in some way, so we ...ed to come together to find the best ...tions we can.

DAN'S TOP TIPS

1. Never be afraid to fail. 'Fail early and fail often' is a motto that my team uses. Failing is learning! It can be difficult when you fail, but it is what you do with that failure that is the important thing. It can be a brilliant career that you can do some good with, so learn from your failures and be noble in your successes.
2. IQ (and/or natural intelligence) is not the most important thing in your studies – the important thing is to work hard. I have never felt that smart, but I love to learn. Doing the best with what you have is a cliché, but it is solid advice.
3. Study maths any chance you get! Take things apart and see if you can understand how they work. Use items around the house (ask your parent's permission of course!) or the hardware store to be inspired. Look for parts that can be used to make machines. Lego is a brilliant resource and you should always have some in the house!

DAN IS WORKING ON A VARIETY OF ROBOTIC VEHICLES. EACH ONE HAS A DIFFERENT FUNCTION. HERE ARE SOME EXAMPLES OF THE TYPES OF VEHICLES AND WHAT THEY ARE DESIGNED TO DO.

WHEELCHAIR-SIZED ROBOTIC VEHICLES

Also known as AgChairs, these will carry out the agricultural work that tractors are usually responsible for, like digging trenches and planting seeds. They are much lighter than tractors, so they won't sink in the mud in wet conditions – this means they can be used for longer and therefore plant more crops. They are also substantially cheaper than larger machines.

MICROWAVE-SIZED ROBOTIC VEHICLES

These robots are the ones that are most likely to get to market first. They include rovers that can use machine learning to detect pests; their small size enables them to easily fit between rows of crops, and they can generate a lot of useful information for farmers.

ROBOTIC VEHICLES WITH ELECTROMAGNETIC SENSORS

These robots, like the others, can perform repetitive tasks very well and without complaining! They can repeatedly dig an electromagnetic sensor over soil as crops are growing, which will provide information on how the soil changes as the crop grows. This information helps farmers to adapt their practices to make more food.

DR DAN FLIPPO
Assistant Professor, Biological and Agricultural Engineering, Kansas State University, USA

FIELD OF RESEARCH
Mechanical Engineering

RESEARCH
Dan's goal is to combine state-of-the-art robotic technology with food production methods to move towards sustainably feeding the world by 2050 and beyond.

FUNDER
United States Department of Agriculture (USDA)

AgChairs vehicles in the 2050RL lab

An AgChairs prototype used for cutting down trees

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Meet real people, learn about real careers

HOW DID PROFESSOR TOM BANIA BECOME AN ASTRONOMER?

What were your interests as a child?
Sports of all types were a big interest, as well as reading anything I could get my hands on. I always knew that I wanted to be a scientist. I was helped greatly by Sputnik (the first satellite ever launched by humankind – launched by Russia), which kicked off the 'space race' between Russia and the USA. As a consequence, the USA funded a host of summer programmes for kids, intended to inspire the next generation of American scientists. It certainly worked for me!

What led you to choose astronomy?
I started university as a chemistry major. In my junior year at Brown University, I discovered that I could actually get paid to do astronomy. That's what

defining your own problems and tackling them through research.

How do you overcome obstacles in your

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What has h

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HOW DID GINNY BECOME A MARINE ECOLOGIST?

DID YOU ALWAYS WANT TO BE A SCIENTIST?
I was always interested in nature. My parents and I spent a lot of time hiking, fishing, observing birds and gardening. My mother started the first recycling programme in our township and was an avid environmentalist. I think this is where I learned that an individual could make a difference. When I got to high school and college, environmental science was my favourite subject and I knew that, ultimately, I wanted to contribute to addressing questions related to the interface between climate change, habitat loss and biology. A few years after my undergraduate degree in finance, I returned to college to focus on this by completing core science requirements and applying to graduate school.

WHICH ATTRIBUTES HAVE MADE YOU SUCCESSFUL AS A SCIENTIST?
It has helped me to be passionate about the process of discovery and conveying the importance of addressing climate change. It has also helped me to be collaborative, honest, and generous with my ideas and my time toward mentoring younger scientists.

WHO OR WHAT HAS INSPIRED YOU IN YOUR CAREER?
I was lucky to be mentored by three amazing men early in my career. The first was my postdoc mentor, Mitchell Sogin, who provided my most valuable learning opportunities in and outside of the lab, and whose confidence in me was so important to my development as a scientist. The next was my second postdoc mentor, Andreas Teske, who showed me what passion for science, and microbiology in particular, really is. My most recent mentor was the late Edward Leadbetter, a retired microbiologist with tremendous knowledge and patience, who worked on his projects in my laboratory, yet managed to encourage my continued learning and critical thinking. Three female scientists at Woods Hole Oceanographic Institution also helped me tremendously by serving as successful female role models. Before I had my own lab, they each provided me with space to work in their labs; they gave me helpful advice and collaborative opportunities. They are Joan Bernhard, Karen Casciotti, and the late Katrina Edwards.

WHAT ARE YOUR PROUDEST ACHIEVEMENTS?
I am most proud of the papers I have published that have students or junior researchers as the lead authors. These are projects that I mentored, that I was passionate about, but that these people took the lead on.

HOW DO YOU 'SWITCH OFF' FROM THE PRESSURES OF YOUR WORK?
This is a skill everyone has to learn – and I learned this slowly, I'm afraid. Hours are needed in each day for yourself, for family and friends, during which there should be no email or other interruptions. I take walks in the woods or on the local beaches, I get together with friends, ride my bike, paddle my kayak, work in my garden or just enjoy my porch. When I can, I travel. Taking breaks out of your day helps you to be healthier and more productive.

RUMEEL JESSAMY

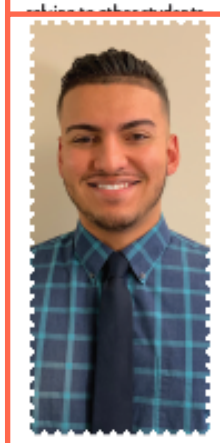
Cryptographic Software Developer, IBM
BS Computer Software Engineering, MS Computer Science, MBA Business Administration, Lincoln University

I was the first lead engineer to work on developing the app. I was responsible for all the mobile application development for two years. I took on the project because I wanted to tackle a new challenge while still studying. I figured it would give me some real-world programming experience.
The main challenge I faced was learning to build IOS and Android software with no prior experience. It took me a few months of reading about the programming language to be able to implement it correctly. I also later taught my methods for debugging and problem-

BRIANNA BLAKE

Major in biochemistry and molecular biology, minor in biology and bioinformatics, Lincoln University

My role in the app process was to create content for the biology questions, by creating problems at different levels of expertise and finding or creating graphics to accompany them. I was also responsible for overseeing the content database, assisting students using the app and evaluating feedback from users.
I got involved in the project for two reasons. Firstly, I wanted a chance to do some undergraduate research, especially with a professor whose classes I really enjoyed. Secondly, I liked the idea of a student-led project, with the freedom to create content designed by students, for students.
Finding questions set at a certain skill level was sometimes



PEDRO MARTINEZ

Major in mathematics, Lincoln University

I was in charge of improving and fixing the 'probability' section of the app. With the assistance of a maths professor and the student programmers, I developed new practice questions and examples, and also fixed some issues with the answer key.
I got involved in the project after a maths professor recommended that I assist students already working on the app. Fixing visual mistakes in the app proved a challenge for me, but I fixed it with the help of the student programmers. Teamwork is key when you reach a difficult hurdle.
During this project, I learnt how to use a new programming language and was also able to gain leadership and teamwork skills through our focus on collaboration.
The app has clear explanations and many examples for practice, so should be useful for many students.
Currently, I am working and revising for exams to become a licensed actuary, after which I can work for an insurance company or investment bank. Once I've gained skills and knowledge of the industry, I plan to start my own consulting company or hedge fund to help people grow their wealth and plan for the future.

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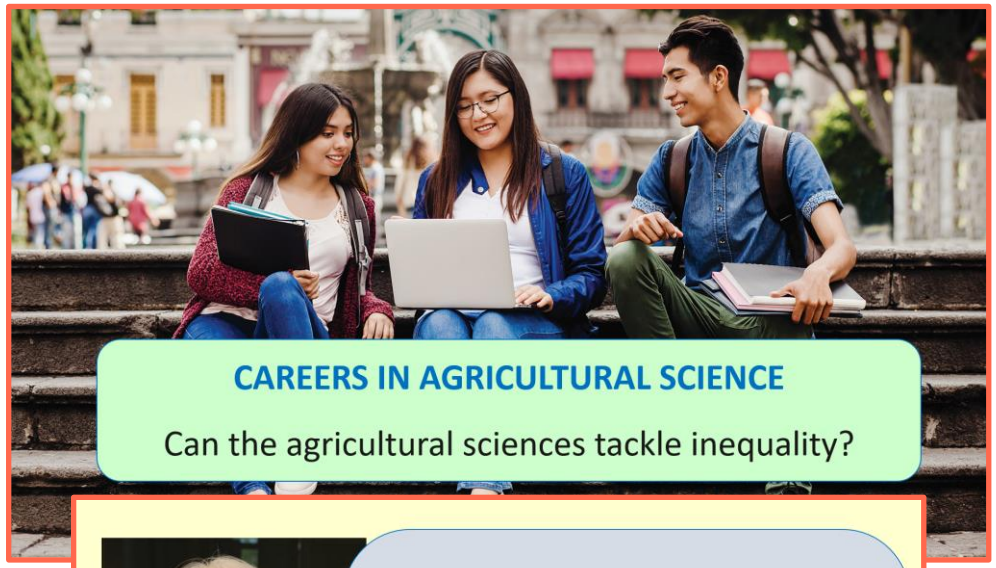

How confident are you in maths and chemistry?

Have a look at our free resources – which ones will help you?

What motivates me to do the work I do?

What is being done to 'raise the gates' in your school or college?

HOW TO BECOME A MOLECULAR BIOLOGIST

- For the UK, the Complete University Guide lists the University of Cambridge, the University of Oxford, Imperial College London and the University of Dundee as the top 4 universities for biological sciences (including molecular biology).
- For the USA, US News ranks Harvard University, Massachusetts Institute of Technology, Stanford University and University of California (San Francisco) as the top 4 universities for molecular biology and genetics.

PATHWAY FROM SCHOOL TO MOLECULAR BIOLOGY

There are a number of degrees that can ultimately lead to a career in molecular biology. As well as molecular biology itself, courses like biology, biochemistry, bell biology, microbiology and genetics all provide clear career pathways to molecular biology.

All these degrees will prefer similar A-level (or equivalent) qualifications within their entry requirements. Biology,

MIKE'S TOP TIPS FOR STUDENTS

1. Don't be afraid to fail, and don't be discouraged by failure. Every scientific success is informed by failures.
2. Focus on your communication skills. Effective communication can get others excited about your work and help you get the resources to broaden your scientific horizons.
3. As well as the obvious subjects like biology and chemistry, think about taking classes in public speaking or similar disciplines in preparation for a scientific career. Many scientists have trouble communicating their results; being confident in this will help you to share your passion with any audience.

Dr Wolyniak introducing students to work in yeast

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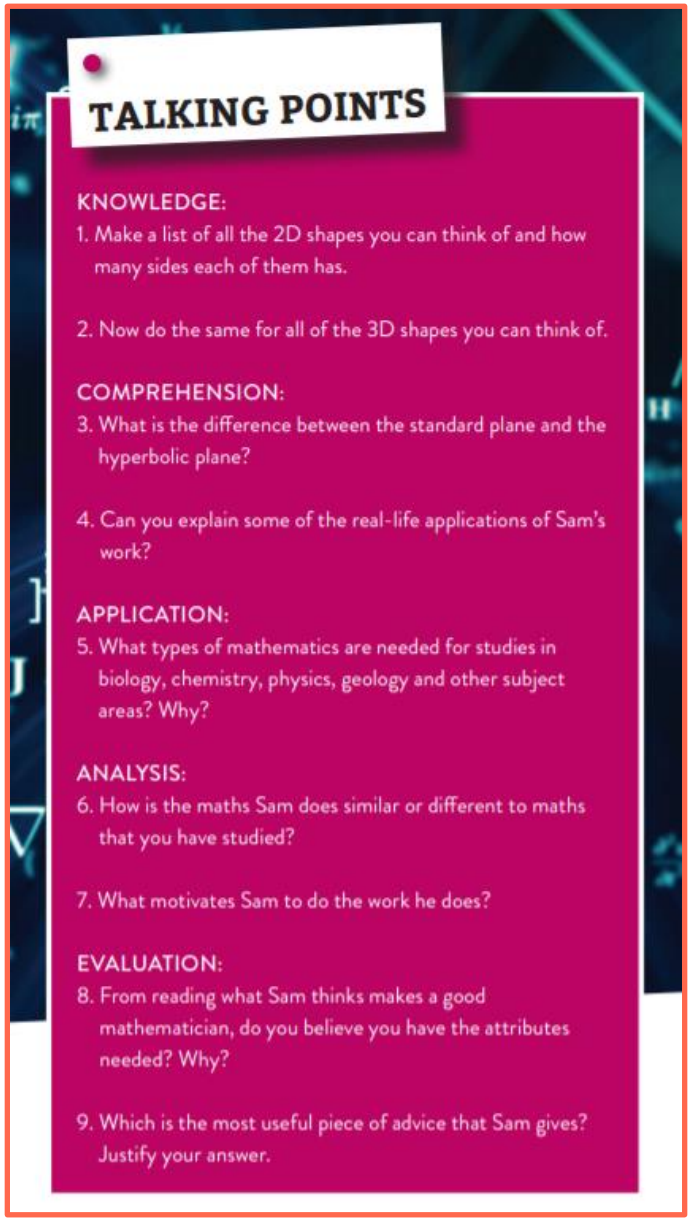
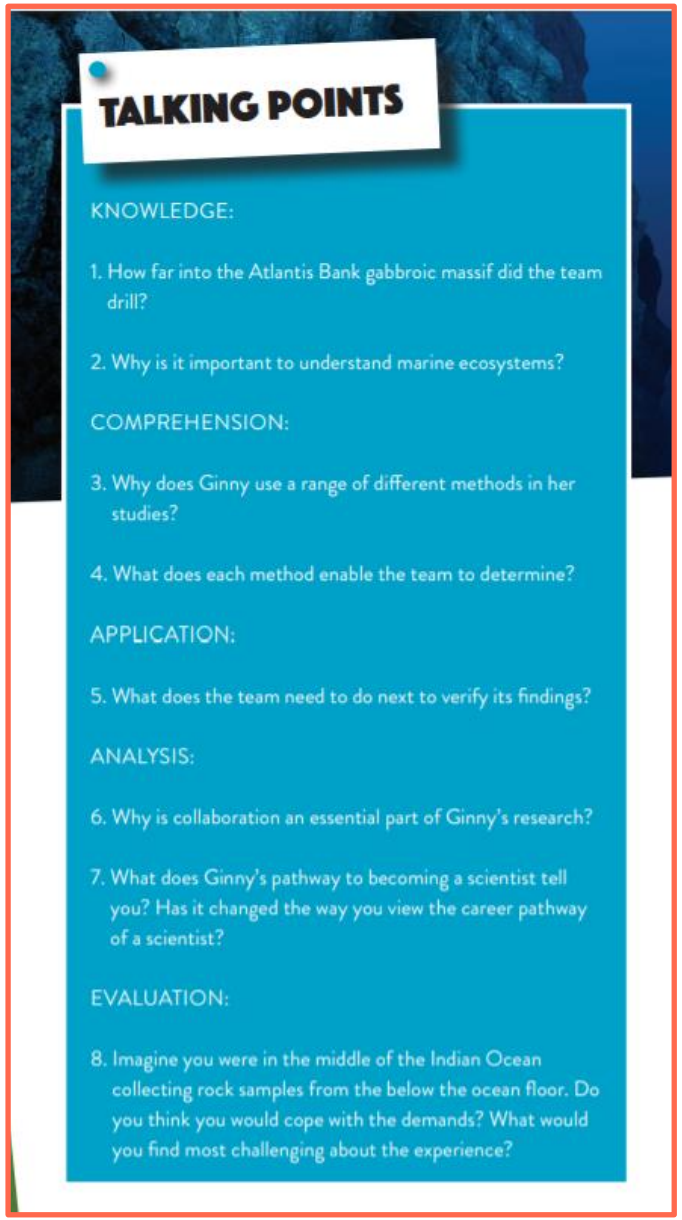
Talking points

What motivates...?

Do you believe...?

Which is...?





What motivates...?

Why is...?

Imagine... What would?

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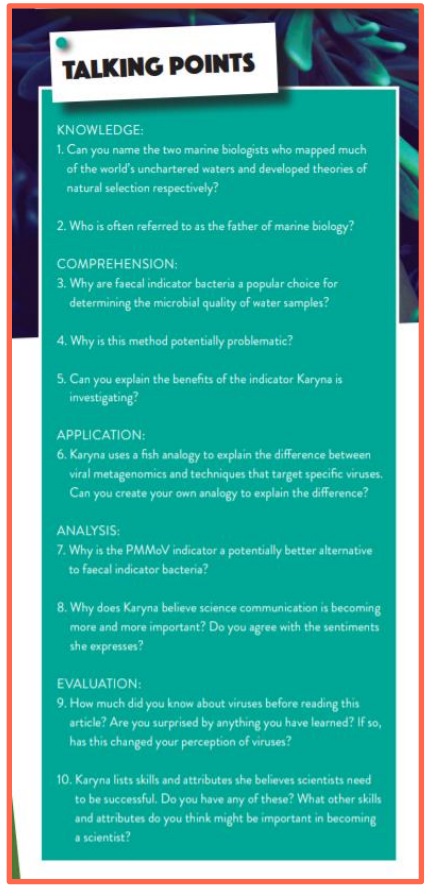
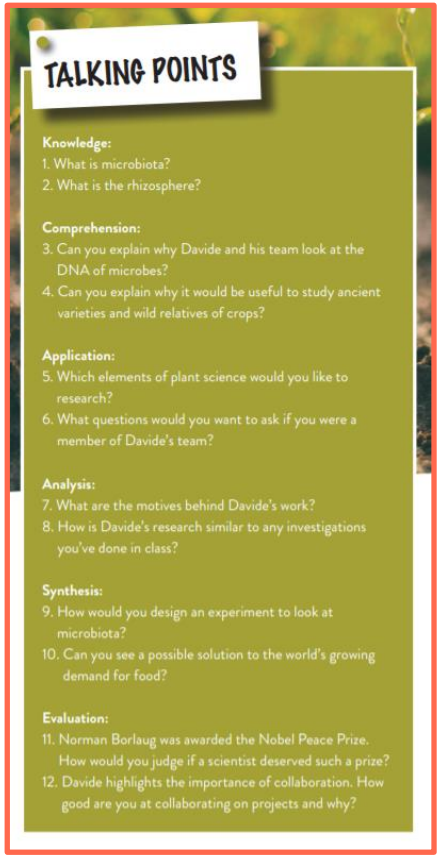
Reflect on their own **interests/skills/passions**



EVALUATION:

How much did you know about viruses before reading this article? Are you surprised by anything you have learned? If so, has this changed your perception of viruses?

Karyna lists skills and attributes she believes scientists need to be successful. Do you have any of these? What other skills and attributes do you think might be important in becoming a scientist?



EVALUATION:

Norman Borlaug was awarded the Nobel Peace Prize. How would you judge if a scientist deserved such a prize?

Davide highlights the importance of collaboration. How good are you at collaborating on projects and why?

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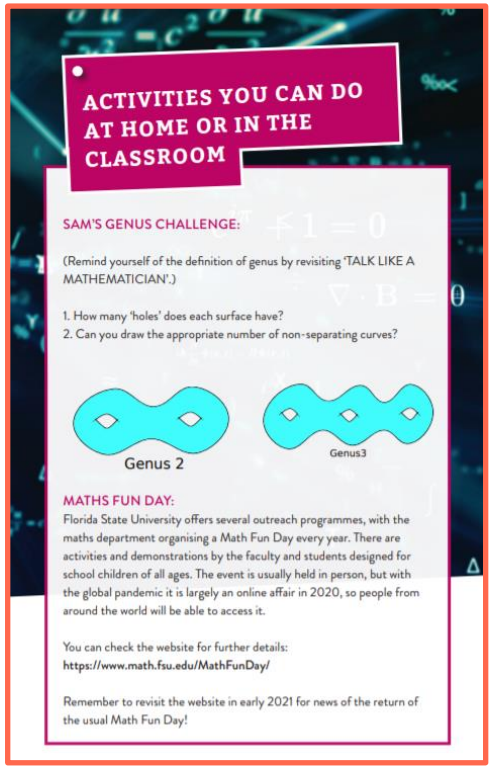
Activities you can do at home or in the classroom



ACTIVITIES YOU CAN DO AT HOME OR IN THE CLASSROOM

SAM'S GENUS CHALLENGE:

(Remind yourself of the definition of genus by revisiting 'TALK LIKE A MATHEMATICIAN'.)

1. How many 'holes' does each surface have?
2. Can you draw the appropriate number of non-separating curves?

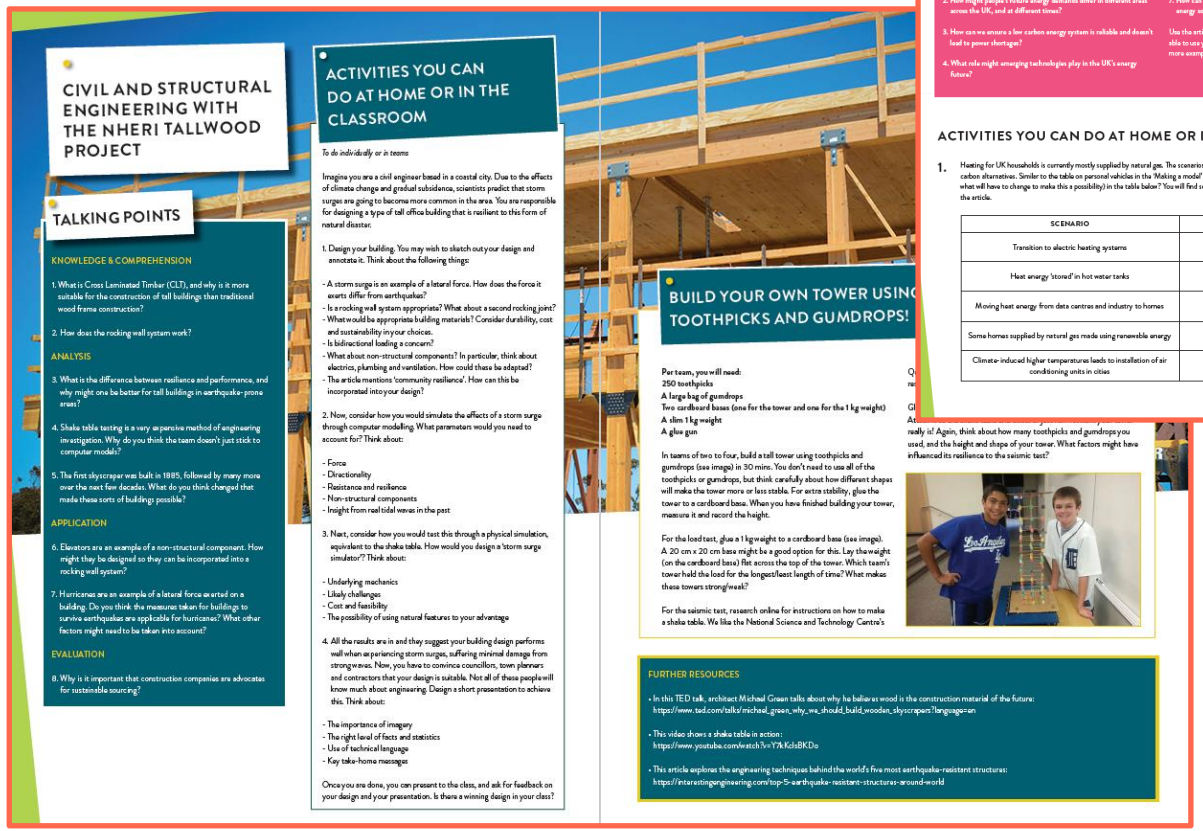
Genus 2 Genus3

MATHS FUN DAY:

Florida State University offers several outreach programmes, with the maths department organising a Math Fun Day every year. There are activities and demonstrations by the faculty and students designed for school children of all ages. The event is usually held in person, but with the global pandemic it is largely an online affair in 2020, so people from around the world will be able to access it.

You can check the website for further details:
https://www.math.fsu.edu/MathFunDay/

Remember to revisit the website in early 2021 for news of the return of the usual Math Fun Day!



CIVIL AND STRUCTURAL ENGINEERING WITH THE NHERI TALLWOOD PROJECT

TALKING POINTS

KNOWLEDGE & COMPREHENSION

1. What is Cross Laminated Timber (CLT), and why is it more suitable for the construction of tall buildings than traditional wood frame construction?
2. How does the rocking wall system work?

ANALYSIS

3. What is the difference between resilience and performance, and why might one be better for tall buildings in earthquake-prone areas?
4. Shake table testing is a very expensive method of engineering investigation. Why do you think the team doesn't just stick to computer models?
5. The first skyscraper was built in 1885, followed by many more over the next few decades. What do you think changed that made these sorts of buildings possible?

APPLICATION

6. Elevators are an example of a non-structural component. How might they be designed so they can be incorporated into a rocking wall system?
7. Hurricanes are an example of a lateral force exerted on a building. Do you think the measures taken for buildings to survive earthquakes are applicable for hurricanes? What other factors might need to be taken into account?

EVALUATION

8. Why is it important that construction companies are advocates for sustainable sourcing?

ACTIVITIES YOU CAN DO AT HOME OR IN THE CLASSROOM

To do individually or in teams

Imagine you are a civil engineer based in a coastal city. Due to the effects of climate change and gradual subsidence, scientists predict that storm surges are going to become more common in the area. You are responsible for designing a type of tall office building that is resilient to this form of natural disaster.

1. Design your building. You may wish to sketch out your design and annotate it. Think about the following things:

- A storm surge is an example of a lateral force. How does the force it exerts differ from earthquakes?
- Is a rocking wall system appropriate? What about a second rocking joint?
- What would be appropriate building materials? Consider durability, cost and sustainability in your choices.
- Is bidirectional loading a concern?
- What about non-structural components? In particular, think about electrics, plumbing and ventilation. How could these be adapted?
- The article mentions 'community resilience'. How can this be incorporated into your design?

2. Now, consider how you would simulate the effects of a storm surge through computer modelling. What parameters would you need to account for? Think about:

- Force
- Directionality
- Resistance and resilience
- Non-structural components
- Insight from real tidal waves in the past

3. Next, consider how you would test this through a physical simulation, equivalent to the shake table. How would you design a 'storm surge simulator'? Think about:

- Underlying mechanics
- Likely challenges
- Cost and feasibility
- The possibility of using natural features to your advantage

4. All the results are in and they suggest your building design performs well when experiencing storm surges, suffering minimal damage from strong waves. Now, you have to convince councillors, town planners and contractors that your design is suitable. Not all of these people will know much about engineering. Design a short presentation to achieve this. Think about:

- The importance of imagery
- The right level of facts and statistics
- Use of technical language
- Key take-home messages

Once you are done, you can present to the class, and ask for feedback on your design and your presentation. Is there a winning design in your class?

BUILD YOUR OWN TOWER USING TOOTHPICKS AND GUMDROPS!

Per team, you will need:
250 toothpicks
A large bag of gumdrops
Two cardboard bases (one for the tower and one for the 1 kg weight)
A slim 1 kg weight
A glue gun

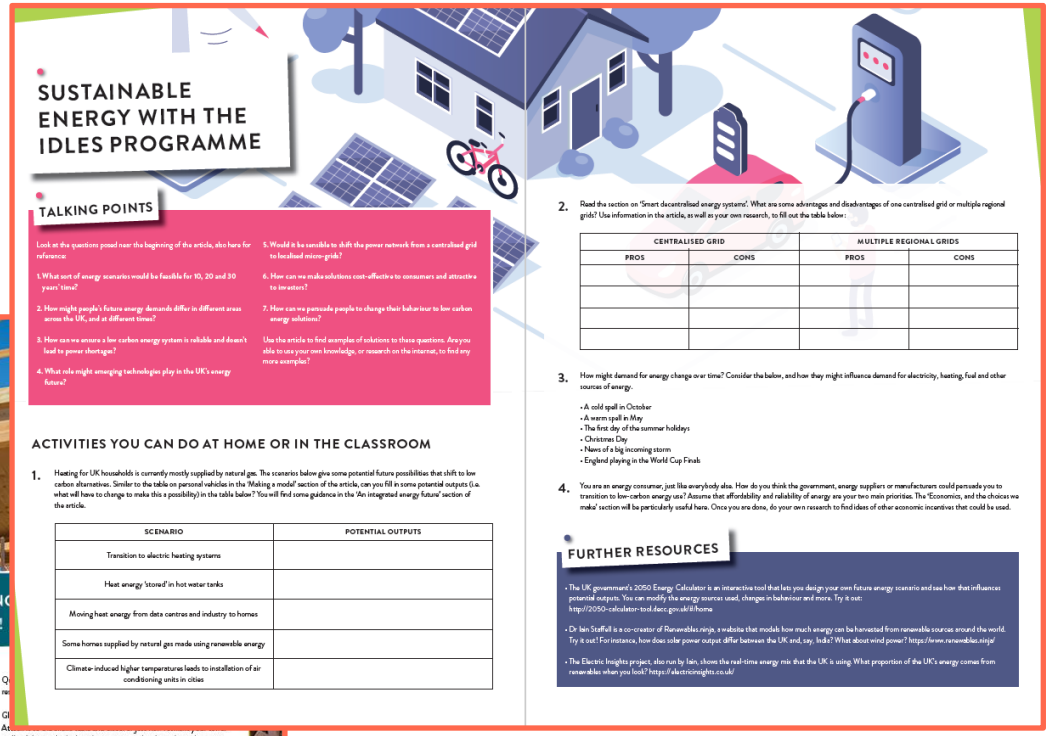
In teams of two to four, build a tall tower using toothpicks and gumdrops (see image) in 30 mins. You don't need to use all of the toothpicks or gumdrops, but think carefully about how different shapes will make the tower more or less stable. For extra stability, glue the tower to a cardboard base. When you have finished building your tower, measure it and record the height.

For the load test, glue a 1 kg weight to a cardboard base (see image). A 20 cm x 20 cm base might be a good option for this. Lay the weight (on the cardboard base) flat across the top of the tower. Which team's tower held the load for the longest/least length of time? What makes these towers strong/weak?

For the seismic test, research online for instructions on how to make a shake table. We like the National Science and Technology Centre's really is! Again, think about how many toothpicks and gumdrops you used, and the height and shape of your tower. What factors might have influenced its resilience to the seismic test?

FURTHER RESOURCES

- In this TED talk, architect Michael Green talks about why he believes wood is the construction material of the future: https://www.ted.com/talks/michael_green_why_we_should_build_wooden_skyscrapers?language=en
- This video shows a shake table in action: https://www.youtube.com/watch?v=YJkKdsBKDo
- This article explores the engineering techniques behind the world's five most earthquake-resistant structures: https://interestingengineering.com/top-5-earthquake-resistant-structures-around-world



SUSTAINABLE ENERGY WITH THE IDLES PROGRAMME

TALKING POINTS

Look at the questions posed near the beginning of the article, also here for reference:

1. What sort of energy scenarios would be feasible for 10, 20 and 30 years' time?
2. How might people's future energy demands differ in different areas across the UK, and at different times?
3. How can we ensure a low carbon energy system is reliable and doesn't lead to power shortages?
4. What role might emerging technologies play in the UK's energy future?
5. Would it be sensible to shift the power network from a centralised grid to localised micro-grids?
6. How can we make solutions cost-effective to consumers and attractive to investors?
7. How can we persuade people to change their behaviour to low carbon energy solutions?

Use the article to find examples of solutions to these questions. Are you able to use your own knowledge, or research on the internet, to find any more examples?

ACTIVITIES YOU CAN DO AT HOME OR IN THE CLASSROOM

1. Heating for UK households is currently mostly supplied by natural gas. The scenarios below give some potential future possibilities that shift to low carbon alternatives. Similar to the table on personal vehicles in the 'Making a modal' section of the article, can you fill in some potential outputs (i.e. what will have to change to make this a possibility) in the table below? You will find some guidance in the 'An integrated energy future' section of the article.

SCENARIO	POTENTIAL OUTPUTS
Transition to electric heating systems	
Heat energy 'stored' in hot water tanks	
Moving heat energy from data centres and industry to homes	
Some homes supplied by natural gas made using renewable energy	
Climate-induced higher temperatures leads to installation of air conditioning units in cities	

2. Read the section on 'Smart decentralised energy systems'. What are some advantages and disadvantages of one centralised grid or multiple regional grids? Use information in the article, as well as your own research, to fill out the table below:

CENTRALISED GRID		MULTIPLE REGIONAL GRIDS	
PROS	CONS	PROS	CONS

3. How might demand for energy change over time? Consider the below, and how they might influence demand for electricity, heating, fuel and other sources of energy.

- A cold spell in October
- A warm spell in May
- The first day of the summer holidays
- Christmas Day
- News of a big incoming storm
- England playing in the World Cup Finals

4. You are an energy consumer, just like everybody else. How do you think the government, energy suppliers or manufacturers could persuade you to transition to low-carbon energy use? Assume that affordability and reliability of energy are your two main priorities. The 'Economics, and the choices we make' section will be particularly useful here. Once you are done, do your own research to find ideas of other economic incentives that could be used.

FURTHER RESOURCES

- The UK government's 2050 Energy Calculator is an interactive tool that lets you design your own future energy scenario and see how that influences potential outputs. You can modify the energy sources used, changes in behaviour and more. Try it out: http://2050-calculator-tool.decc.gov.uk/#/home
- Dr Iain Staffell is a co-creator of Renewables.ninja, a website that models how much energy can be harvested from renewable sources around the world. Try it out! For instance, how does solar power output differ between the UK and, say, India? What about wind power? https://www.renewables.ninja/
- The Electric Insights project, also run by Iain, shows the real-time energy mix that the UK is using. What proportion of the UK's energy comes from renewables when you look? https://electricinsights.co.uk/

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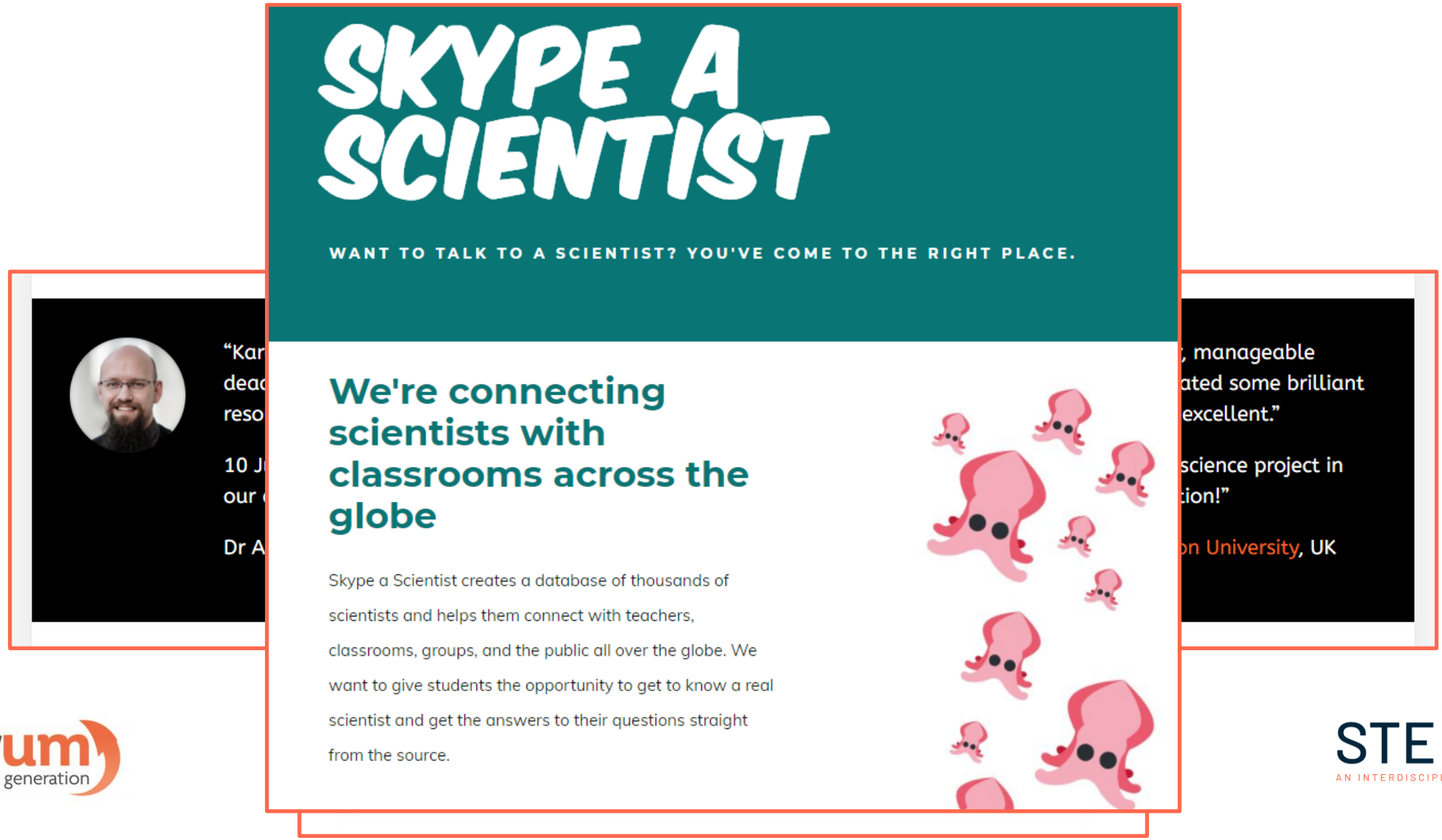
Keep the **conversation** going…



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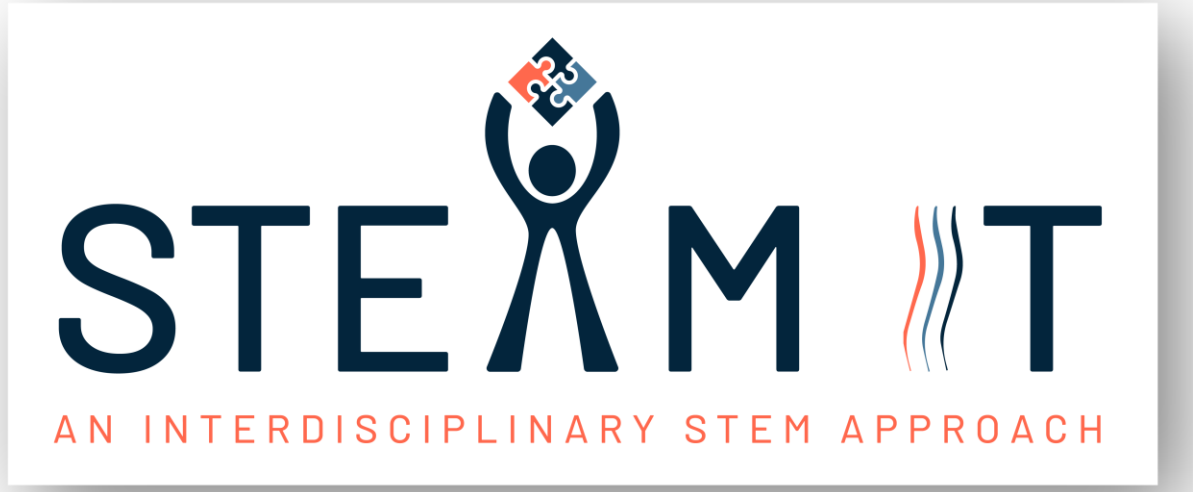

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