Date: October 2023

Dear Readers

Welcome to the first edition of our science newsletter for this academic year!

It has been an extremely busy term, which saw our new Year 12 students start our sixth form courses with enthusiasm. They have started conducting some of their assessed practicals and have also started applying for work placements, showing their passion and dedication to their subjects.

Year 13 students have been focussing on writing their personal statements and have started applying for some rigorous and exciting university courses such as medicine, dentistry, biology with biomedical sciences, physics, computer science and engineering.

It has also been an exciting time in the world of science. Some of the highlights include:

- Scientists have edited the genes of chickens to build resistance to bird flu, which suggests a possible way to protect flocks from future outbreaks. This is only the first step and years of further testing lie ahead, and regulatory approval is needed before the chickens can be farmed for human consumption.
- A new technology uses waste plastic to produce hydrogen, a clean fuel. The process also produces high-quality graphene as a byproduct.
- As ITER's construction nears completion, JET, the world's largest tokamak and the UK's fusion site, ends it experiments after 40 years of operation. JET and ITER both look to control nuclear fusion to make it a viable energy source.

As always, I am delighted to introduce a range of articles, just a selection of the large number of submissions we received, all of which are researched and written by our Year 12 and 13 scientists.

Enjoy the half-term break and I hope you all enjoy learning something new!

Ms Patel

Lead Practitioner of Science

The slugs that can photosynthesise by Lauren Chen

Living in salt marshes along the east coast of North America, a species of slug known as Elysia chlorotica (which looks like a bright green leaf) can go about a year without eating and live like a plant! But how is this even possible? Luka Seamus Wright explains this in greater depth, detailing the incredible adaptations of these mixotrophs.

First, we must understand that animals are known as heterotrophs. This means they can't produce their own food- they're consumers of other life. Meanwhile, plants are known as autotrophs. They can produce their own food. Elysia chlorotica on the other hand is what's called a mixotropth. It can consume food, just like animals but also produce their own food through photosynthesis just like plants.

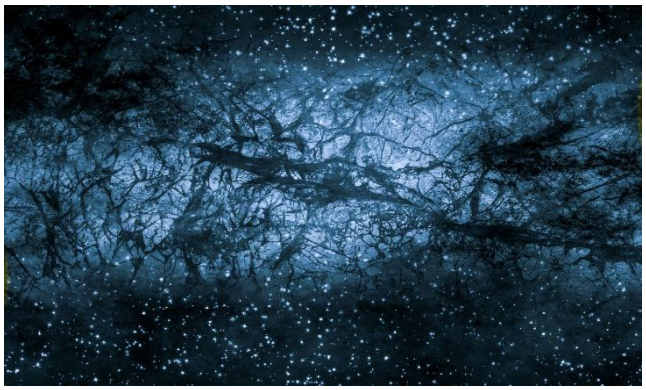
One incredible adaptation of Elysia chlorotica is it can steal its ability to photosynthesise from the algae it eats by piercing the algal cells. Radula (which are specialised pointy teeth) allows Elysia chlorotica to do this and as a result, it sucks the cell empty and digests most of its contents. However, the chloroplasts remain intact and branch throughout its flat body leaving a more leaflike appearance.

As incredible as this adaptation is, there are more than 70 species of slug that steal chloroplasts from their food. But only Elysia chlorotica and a few closely related species can hold onto these chloroplasts for a greater period. This is because chloroplasts can repair themselves without having to rely on their host cell. Therefore, they can survive much longer inside the slug.

In conclusion, scientists believe that the processes by which Elysia chlorotica becomes photosynthetic are reminiscent of the origin of all plants. You see, single-celled animals preyed on cyanobacteria. Some of these tiny plants were not digested and lived on in the animal cells, eventually giving rise to chloroplasts. But these plants were soon consumed by other animals which hijacked the precious chloroplast… just like Elysia chlorotica.

What is dark matter? by Arian Kurd

The universe is made up of matter. Almost everything one can think of that exists in the universe is made of matter, such as the stars and the planets. All atoms are made of matter. Yet despite this, tis matter only makes up 15% of matter in the universe: the other 85% is dark matter.



Dark matter is called 'dark' because it is impossible to see dark matter. The only reason we are certain of its existence is because of the gravity it has and how it affects the galaxies around it. Machines can pick up where dark matter is most concentrated through the method of g ravitational lensing (a method that relies on the fact gravity distorts space-time and bends light behind it so we can see the light). Other than through gravity, it does not interact through anything else: it does not experience drag, electrostatic attraction nor can it reflect light, for example.

Dark matter was first discovered by Fritz Zwicky in 1933. The discovery was made when he was investigating galaxy clusters (galaxies that orbit around each other). Orbits can only occur if the speed of the orbiting body is fast enough to not fall into what it orbits but slow enough so that it does not escape the orbit. The galaxies Fritz Zwicky observed move at speeds far higher than what could reasonably allow for an orbit, yet they were in orbits, nonetheless. For this to

occur, there must be a lot more gravity than what was calculated. This meant there must be a lot more mass than the mass that could be observed. This mass was called ‘Dunkle Materie’ by Fritz Zwicky, and later called dark matter. The amount of dark matter was calculated by seeing how much more mass was needed for gravity to hold the cluster galaxies in orbit. This resulted in us knowing there is a lot more dark matter than normal matter.

Almost nothing is known about dark matter other than its gravitational effects. We do not know what it is made of, but we do know it is not made from material left behind by dead stars. It is believed by most scientists that dark matter is made of exotic particles, such as axions or weakly interacting massive particles (WIMPs), but this is not certain.

Dark matter is mysterious, especially so considering it makes up 85% of all matter, which shows us how little of the observable universe we see. This is exacerbated by the fact that both matter and dark matter only make up 32% of all matter and energy; 68% of the universe is made of another substance called dark energy. Despite this, scientists are getting closer to discovering dark matter with recent advancements in technology such as quantum computing and are thus getting closer to discovering a lot more of our observable universe.

Arsenic, the poison of kings by Kelly Eerka

Arsenic is frequently referred to as a metal although it is a metalloid and is a solid with a steel grey colour. It is notoriously known as the ‘king of poisons’ or ‘the poison of kings’ as it was used by nobility and royalty to kill rivals. For instance, Emperor Nero of the Roman Empire used arsenic to poison the soup of his younger stepbrother Britannicus. Or the Italian nobility of the Medici and the Borgia, as arsenic was their go-to poison to permanently remove of rivals. Arsenic is no longer used as a poison; however accidental arsenic poisoning does occur. People can get arsenic poisoning from water sources in which dissolved arsenic minerals levels are abnormally high. But why does it kill?

Arsenic is found in the same group as phosphorous on the periodic table. In fact, the two are immensely similar in terms of structure and properties. The only difference is that phosphorus is essential for our life and arsenic is a one-way ticket to the afterlife. These similarities allow arsenic to mimic phosphorous in chemical reactions such as the production of ATP (our main energy source) causing the disruption of vital chemical reactions in our body. Arsenic can harm every organ in our bodies though this property alone. Some of the symptoms of arsenic poisoning are diarrhoea, vomiting and multiple organ failure which could result in death. However, if detected early, death can be prevented with an antidote referred to as dimercaprol which neutralises the toxicity as it absorbs the arsenic.

However, even with these toxic properties, arsenic has been used for some treatments. German chemist Paul Ehrlich and Japanese bacteriologist Sahachiro Hata discovered the arsenic compound Salvarsan. It was used as an effective treatment for syphilis at the time. Unfortunately, the compound had many additional serious side effects such as liver damage. It was in used until Alexander Fleming’s (and Flory and Chain’s!) penicillin became available, which was far safer and had less side effects.

Work Experience

Many of our sixth formers participate in a wide variety of STEM-based workshops and programmes throughout the year. They also secure placements and give up part or all of their summer holidays to complete a wide variety of projects with current scientists, working on the most up-to-date projects and resarch!

Lloyd Williams: Nuffield Research Project, In2Science and STEM Smart

"An overall welcoming experience! I got to see and experience how PhD students work on a day-to-day basis. It was a great feeling knowing that what you were learning or researching has almost never been researched before and so, I was one of the first also being allowed to study this.

For my research we looked at quantum mechanics and how we can use quantum computers to access qubits (quantum bits) and higher energy levels. The experience is very beneficial for your personal statement, particularly for mine as I received an interview from the University of Oxford, where the person interviewing me specialised in what I had been researching in during my placement".

Shalom Ogunrinde (Year 11): Zeiss Summer School with Imperial College London

This was the first year Imperial College ran this programme and Shalom beat students from over 100 countries to gain one of the 24 positions! A phenomenal achievement.

"My favourite thing during the Zeiss Imperial Summer School was learning about and creating composites. We competed with each other to see which type of mixtures we could create. I also learnt about the use of microscopy to benefit the environment.

Overall, I found the summer school useful as it taught young people about the different career pathways they can take in material science, especially focussing on improving the environment".

Adzor Atkins: Stem Potential and STEM Smart

"I applied and was accepted onto Imperial College London's STEM Potential programme. During this programme, I carried out the multi-step synthesis of aspirin for the first time and it was inspiring to see how the theory of functional groups that I have learnt in my chemistry lessons was being utilised in a real-life application.

I also had the opportunity to use a Fourier Transform InfraRed (FTIR) spectrometer and melting point apparatus, to assess the purity of my synthesised aspirin."

What are the auroras? by Khang Phan

An aurora is a spectacle of light which is commonly observed by the Earth's magnetic poles. Every few months, these lights can be observed close to the Earth's magnetic poles, with Aurora Borealis being found near the North and Aurora Australis being found near the south.

The journey begins at the Sun's outer most region, the Corona, where the immense quantity of thermal energy causes protons and electrons to be discharged from hydrogen atoms -due to powerful vibrations- at a velocity of 446 miles per second which even the Sun's great gravitational pull cannot contain. Thus, these ejected protons and electrons group together to form and electrically charged gas known as plasma. This movement of plasma throughout space is known as the solar wind which would normally collide with the Earth, but the Earth is able to protect itself with the help of the magnetosphere. The magnetosphere is formed by the Earth's magnetic currents and helps by redirecting the solar winds around the Earth.

However, even the magnetosphere can be disrupted by coronal mass ejections where large quantities of plasma are released by the Sun by solar flares, or sunspots. When this large mass of plasma collides with the magnetosphere, a magnetic storm is formed which can stress the magnetosphere and cause it to snap. During this process, some of the detoured particles are flung towards the Earth. The retracting band of magnetic field drags the particles down to the aurora ovals where the Northern and Southern lights are found.

On entering our atmosphere, the charged protons and electrons encounter neutral nitrogen and oxygen particles which are commonly found in the Earth's atmosphere. When the charged particles collide with the neutral oxygen and nitrogen particles, energy is transferred to the neutral particles, causing photons to be released. These photons are small bursts of energy which are in the form of light and the colours that we see from this light depends on the wavelength of the atom's photon. Photons released by oxygen atoms have been observed to be responsible for the green and red colours, whereas nitrogen atoms are responsible for blue and deep red hues.

How does Sunscreen Work? By Georgia Williams

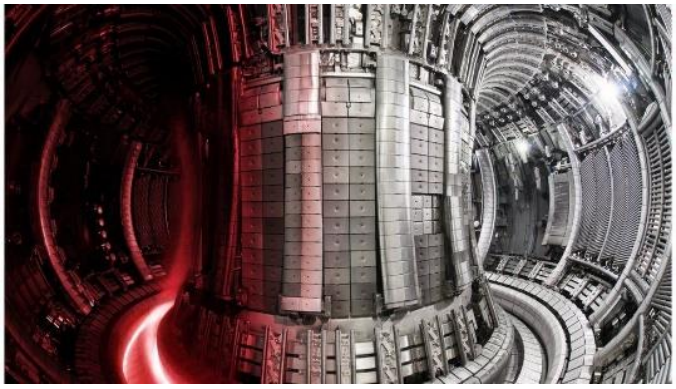
We have all most likely used sunscreen in our lives at least once. We have all used it because we were told it would protect us from the sun's harmful rays. But how does it do that? It is important to use sunscreen in our lives every day, even if the weather is not bright and sunny, although many people do not. Sunscreen is key in protecting your skin from UV rays which are very harmful to mammals. It is made up of stabilising agents which help the product to maintain its consistency and shelf life. The active ingredients in sunscreen, which are the ingredients that help protect people from the sun, make up about 20% of the formula in sunscreens.

Chemical sunscreens contain UV filters which absorb UV radiation and then they transform the energy into heat, which is then released from the body. Chemical sunscreens are quite dangerous as there are certain health risks such as the chemicals from the sunscreen entering the bloodstream. The American Academy of Paediatrics do not recommend using this sunscreen on children as their endocrine system is still developing. It is also not recommended for people with certain conditions like rosacea, melasma and acne which could worsen and irritate these conditions, and even possibly getting an allergic reaction. With chemical sunscreens, the skin absorbs the chemicals, so it does not leave a white cast. However, mineral sunscreens (physical sunscreens) act as a layer on the skin which is then a shield to any UV rays that

are trying to destroy and harm our bodies. Physical sunscreens are good as they immediately protect the body from the sun as soon as it is applied, and they are good for people with sensitive skin. However, some people do not particularly like using mineral sunscreens as they leave a white cast, and they must be reapplied quite often. These sunscreens reflect the rays so that they are going away from the body instead of absorbing them.

In addition, we need to consider the SPF value. On a bottle of sunscreen, you would often see SPF 15, 30, 50+… but what do they all mean? Well, it is the extent of sunscreen protection you can gain from a product, but only against UVB rays and not UVA rays. Both UVA and UVB rays are produced by the sun and sunscreen contains chemicals that prevent UV rays from hitting the skin. A lot of sunscreens contain other ingredients, such as antioxidants that counteract the harmful free radicals that UVA rays produce. Some of these antioxidants are vitamin C and E and compounds from plants. The SPF also measures how long the sunscreen lasts before it begins to wear off and not protect the skin.

Harnessing Nuclear Fusion by Petro Koumarakou



Energy is the fundamental currency of our universe and there are various ways that humanity obtains it, but all of them come with drawbacks. Fossil fuels are a finite resource and toxic, nuclear fission releases dangerous nuclear waste and renewable energy sources such as solar and wind are unreliable as they are dependent on the weather. However, the sun seems to release unlimited energy which we have been unsuccessful to harvest to its full potential with our current technology and concepts like the Dyson sphere seem as nothing more than science fiction. So why don't we build our own star on earth?

Stars burn due to nuclear fusion. This is a thermonuclear process which means that the ingredients- hydrogen atoms- must be heated to such a degree that the atoms are stripped of their electrons making a plasma were nuclei and electrons move freely. Then even more heat is needed to increase the speed of the particles and overcome the repulsion of the positively charged nuclei, merging them and creating helium nuclei which are heavier than hydrogen releasing energy in the process. Stars easily reach these temperatures due to the pressure in their core created by their enormous amount of mass.

Scientists hope to harness this energy release through a new generation of power plant, the fusion reactor. Although we are unable to replicate the sun's method of nuclear fusion scientists have invented two ways of making plasma hot enough to reach the same results: magnetic confinement reactors and inertial confinement reactors.

Magnetic Confinement Reactor: It uses a magnetic field to squeeze the plasma into a circular chamber were the reactions take place. Magnetic Confinement Reactor, such as the I.T.E.R. in France, use superconducting electromagnets cooled with liquid helium reaching only a few degrees above absolute zero.

Inertial Confinement Reactor: It uses pulses from super-powered lasers to heat the surface of a pellet of fuel, imploding it and making the fuel hot and dense enough to fuse.

However, all of these reactors are in experimental phases as they require more energy to operate then they produce in fusion. This means that currently nuclear fusion is not a commercially viable source of energy and there is uncertainty if even with technological development it will ever be. But its advantages over other sources of energy make it a worthy gamble to spend money for as a glass of sea water could be used to produce enough energy equivalent to burning a barrel of oil with no waste. This is because fusion reactors would use the hydrogen- which is abundant in sea water- and helium 3- which can be found on the surface of the moon- as fuel.

Sixth Form Super Curricular Reading

With half-term on the horizon, it is always a good idea to take some time out and engage with some new reading.

Have a look at the suggestions below that students and staff have recommended!