FHSTEM

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2019

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EDITOR'S note

The prevalence of STEM in our society is pivotal to understanding how the world works. With this knowledge, advances have been made in a myriad of fields and we believe that it is highly relevant to all disciplines. We compiled this collection of articles hoping to extend your knowledge and interest in the field.

Enjoy!

Giorgia and Nour
Academic Ambassadors

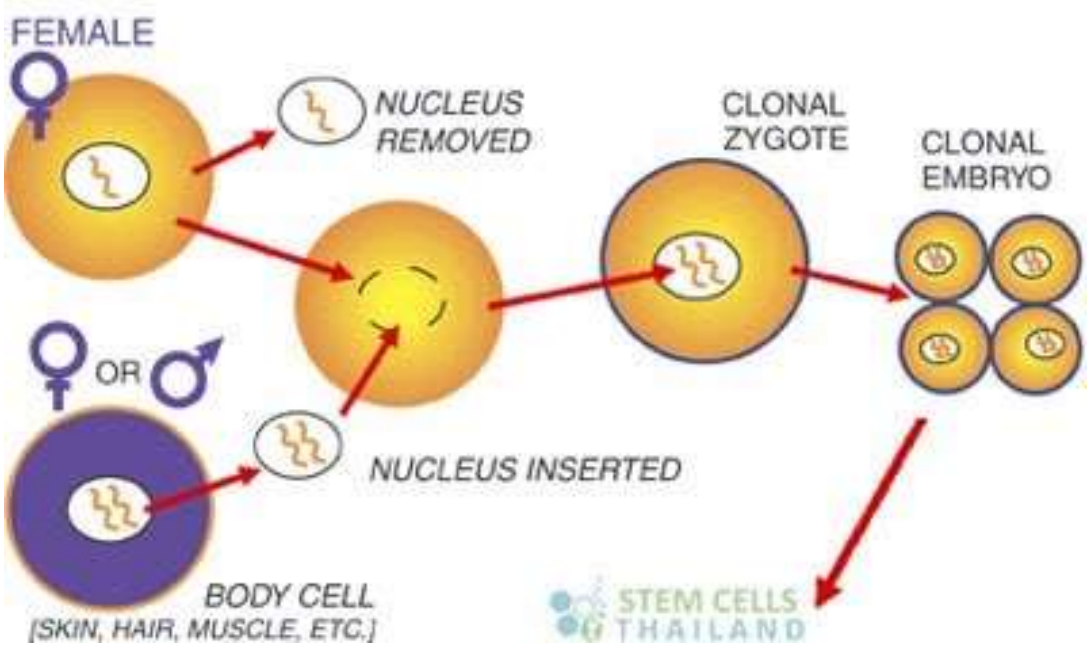
SCIENCE

BIOLOGY

Science Breakthrough or Ethical concern?

By Nikolina Kovacevic

On the 27th November 2017 the first ever non-human primates were successfully cloned through a technique named "SCNT" – somatic cell nuclear transfer. This is where the DNA is moved from the nucleus of one cell into an egg cell that has previously had its original DNA removed; the cell is then implanted into a surrogate animal. This same technique was used just over two decades ago in the cloning of other animal species creating the infamous Dolly the Sheep.



This recent scientific breakthrough has initiated a debate amongst scientists as to whether or not this is a progressive movement for the future of human disease research, or whether this is a cause for ethical concern. Some have argued that the data collected on monkey species that are genetically similar to humans has the ability to widen our understanding of human diseases. This could drastically improve our knowledge of how certain diseases affect our cells, and furthermore could potentially lead to discovery of new drugs and cures for them. However, others have opposed this idea, expressing how this technology raises the possibility of developing human cloning experiments, which not only are unethical, but could have devastating consequences on society.

Furthermore, the process has been described as a disorganized and dangerous method of cloning, which begs the question as to whether or not it is safe to use it for the development of cures for human disease. Moreover, what creates further apprehension is that the successful clone of the monkey cell was achieved only following seventy-nine previous attempts. Although many other mammals, such as rats and cattle, have been cloned via the same method, to what extent is it safe to use for the research of human disease? Furthermore is it right to experiment on other species for the benefit of our own? Perhaps a more effective approach would be to develop a new method of cloning or limiting the number of attempts to clone a given species.

On the one hand we should appreciate the fact that we humans have developed a way in which to clone organisms, a massive scientific breakthrough. On the other hand where does the boundary between discovery and taking advantage of these animals lie?

Sources: https://www.bbc.co.uk/news/health-42809445

Are Gene-edited farms possible in the future?

By Marietta Goulandris

The meteoric growth of genetic research is not to be underestimated. Immense progress is being made in the field of genetics that will soon have life changing consequences on not just humans, *but also* animals. Gene-edited crops and farm animals are on the horizon and the discoveries that scientists have made regarding animal genetics will not just change lives but also save them.

Porcine Reproductive and Respiratory Syndrome (PRRS) is a deadly respiratory disease which causes breathing problems and deaths in young animals, and if pregnant sows become infected, it can cause them to lose their litter. Vaccines have mostly failed to stop the spread of the virus – which continues to evolve rapidly, costing the pig industry around $2.5 billion (£1.75bn) each year in lost revenue in the US and Europe alone. Recently, however, scientists have been able to edit animals' DNA to make them resistant to this.

Undoubtedly, this raises concerns; a lot of consumers are hesitant to eat animals whose DNA has been tampered with. However, the world health organization has stated no effects on human health have been shown as a result of the consumption of such [gene-modified] foods by the general population in countries where they have been approved. In addition it is felt that there is also a potential ethical problem that having disease-resistant animals could lead to farmers avoiding the improvement of the welfare of their livestock.

How exactly did they manage to alter this gene?

Researchers at the University of Edinburgh were able to delete a small region of pig DNA, which the virus infected using a receptor on the cell's surface called CD163. They put this technique to the test and exposed the virus to four pigs whose genes had been altered to be resistant to the PRRS virus and they were unaffected. In order to dispel concerns that the pigs had been weakened by gene editing, Dr Christine Tait-Burkard also ran tests and showed that the pigs were neither harmed nor weakened by the process of gene editing. She also proved that *no* foreign genes entered the pig.

There are some interesting and valid arguments against the use of this new technology - Helen Browning, a member of the Soil Association feels that the process of gene editing does not tackle the heart of the issue. She herself has 30 pigs on her organic farm in Wiltshire and has never faced any problems with PRRS due to the pigs having a high living standard and being constantly outdoors. Ultimately, she thinks that, through pigs being resistant to such tragic illnesses, farmers will no longer feel the need to take proper care of them and, as a result, keep them in even worse conditions. Luckily for Ms Browning, this technology has not yet been approved and public debate has yet to occur. However, if the studies are successful, it seems highly probable that gene-editing will commence in the near future.

This marks the beginning of an enormous, pivotal change in the field of genetics, but after the removal of the PRRS gene, what is next in store for the future of genetic engineering and how far will it go?

Sources:

https://www.ed.ac.uk/roslin/news-events/latest-news/gene-edited-pigs-resistant-billion-dollar-virus

https://www.theguardian.com/science/2018/jun/20/scientists-genetically-engineer-pigs-immune-to-costly-disease

https://www.bbc.co.uk/news/science-environment-44388038

CHEMISTRY

How to save the world: the impact of plastics on our planet

By Carolina Lanz

Plastic has been the subject of much controversial debate, particularly over the past few years, as the problems it presents for our planet have become more and more apparent. As speaker Emily Penn, Oceans Advocate, expressed, the impact of plastic on our oceans is having a catastrophic affect, one leading to islands of plastic debris miles beyond the mainland. Particularly harmful are microplastics.

Microplastics, as the name suggests, are tiny pieces of plastic typically less than 5mm long which result from the breaking down of larger bodies of plastic into increasingly smaller pieces. Despite being hardly visible, they have an arguably even more toxic and dangerous effect than the larger pieces of plastic, as they are much more easily ingested by marine life.

In the summer of 2017, an expedition was led around the coast of Scotland on a Greenpeace ship named *Beluga II,* with the aim of documenting the presence of plastics in the feeding grounds of marine life. Over the course of a couple of months, the team undertook nearly fifty manta trawls - a net system used for sampling the surface of the ocean - and found microplastics in two-thirds of the samples. This is a clear indication of how much plastic ends up in the stomachs of marine life, which not only has a detrimental effect on them, but also on the whole food chain which includes us humans.

Greenpeace: Beluga II

In addition, there are many uninhabited islands - including one known as Barents Island, far north in the high Arctic - which, despite never being home to human residents, has beaches covered in bits of plastic. The majority have been carried by ocean currents, possibly travelling up to several thousand miles. Many more remote regions of the world

are in a similar state, including the deepest place on earth, the Mariana Trench in the Western Pacific Ocean, measuring up to 11km deep. Scientists from Newcastle University discovered that every single sample taken from the deepest point of the trench contained microplastics. Furthermore, the highest density of plastic ever to have been documented was on an uninhabited coral atoll named Henderson Island located in the South Pacific, where an estimated 38 million pieces of plastic was found, with items from Germany, Canada and other extremely distant places. The impact of our actions should not be underestimated and will be visible across the globe for generations to come. According to the Earth Day Network factsheet, the amount of plastic in the ocean is set to increase tenfold by 2020 and by 2050 there will be more plastic in the oceans than there are fish (by mass)!

Now is the time to change our ways and aggressively combat plastic pollution before it becomes apocalyptic. Given the damage already done, simply recycling is not enough. We have to comprehensively eliminate plastics from our daily lives. Some of the most obvious actions we all can take is to kick the plastic bottle habit and instead adopt reusable bottles. We can eliminate our use of coffee cups, as of the 2.5 billion coffee cups that British people use each year, only a mere 0.25% are recycled. We can also ban plastic bags from our lives by replacing them with reusable shopping bags.

Some perhaps less obvious ways to go as plastic free as possible were exemplified by Alice Thomson, Columnist of The Times of London, who suggested rethinking everything plastic in your home from plastic containers of things like soap, food, beauty products and drinks, to random daily items like hangers, ear buds and pens. As Will Callum showed in his book, *How to Give Up Plastic,* 'the problem of plastic pollution affects us all, and is one for which we all share responsibility as individuals but also, more importantly, collectively.' Therefore if we want to ensure a sustainable future for generations to follow, we must take a **collective** stand against it now.

Sources:
www.climate.nasa.gov

How To Give Up Plastic, Will McCallum (Head of Oceans, Greenpeace UK)

Class A Drugs and the Chemistry Behind Them

By Elisa Schapira, Nour Akhrass & Giorgia Merighi

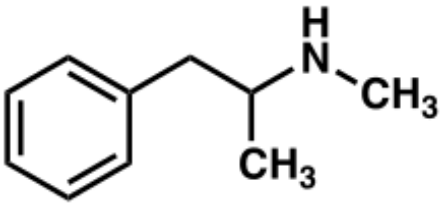
SECRET KFC DRUG TUNNEL DISCOVERED BY US AUTHORITIES

On 13th August 2018 US authorities discovered a secret drug tunnel which ran from a former KFC in Arizona, to Mexico. The passage, which was measured to be 180m long ran from the basement of an old restaurant in San Luis to a trap door under a bed in a home in Mexico, said US officials. The drugs are believed to have been pulled up through the tunnel with a rope.

The authorities were alerted to the tunnel after arresting suspect Ivan Lopez as he was exiting the building with containers holding 118kg of methamphetamine, 6kg of cocaine, 3kg of fentanyl, and 19kg of heroin. street value of these Class A drugs was found to be worth more than $1million.

The Science Behind Class A Drugs:

METHAMPHETAMINE

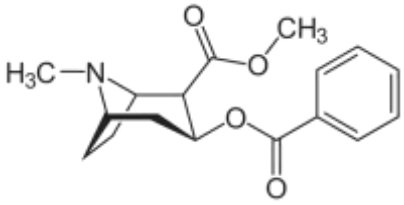


Methamphetamine is a powerful, highly addictive stimulant that affects the central nervous system.

Effects: Reduces the binding of dopamine to dopamine transporters in the striatum, the area in the brain crucial to memory and movement.

It causes increased attention and decreased fatigue, increased activity and wakefulness, a decreased appetite, a sense of euphoria, increased respiration, a rapid/irregular heartbeat and hyperthermia (elevated body temperature).

COCAINE

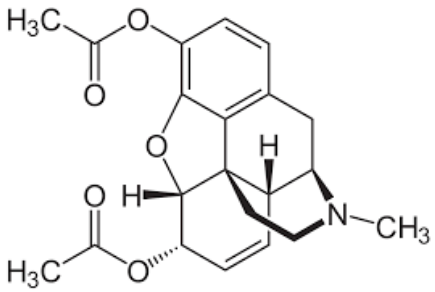


Cocaine hydrochloride is a powerfully addictive stimulant that comes from coca leaves.

Effects: Increases levels of the chemical messenger dopamine in the brain. Cocaine prevents dopamine from being recycled, causing large amounts to build up in the space between two nerve cells, stopping their normal communication.

Users tend to experience feelings of euphoria, increased energy, inflated self-esteem, elevated mood. However, cocaine also causes a loss of appetite, feelings of restlessness, irritability and anxiety, panic and paranoia. It can also disturb heart rhythm, inducing cardiac arrest, strokes and seizures, which can lead to sudden death.

HEROIN

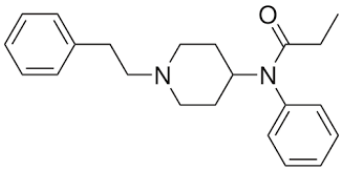


Heroin is a very addictive opioid drug. It is a modified form of morphine, which is used as an analgesic (pain-reliever).

Effects: Binds to neurotransmitters and activates specific receptors in the brain that regulate pain, hormone release and feelings of well-being and stimulates the release of dopamine.

Users feel an intense surge of pleasurable sensation—a "rush." The rush is usually accompanied by a warm flushing of the skin, dry mouth, and a heavy feeling in the extremities. Nausea, vomiting, light sensitivity, cyanotic (bluish) hands, feet and lips and severe itching may also occur. After the initial effects, users will usually be drowsy for several hours; mental function is clouded; heart function slows; and breathing is also severely slowed, sometimes enough to be life-threatening as it can lead to coma and permanent brain damage.

FENTANYL



Fentanyl is a potent, synthetic opioid analgesic which is extremely good for controlling pain, but it has a huge abuse potential. It is 80 to 500 times stronger than morphine.

Effect: Fentanyl works by binding to the body's opioids receptors - areas controlling pain and emotions. When this drug binds to these receptors, they increase dopamine levels, producing a state of euphoria and relaxation.

Similar to heroin, fentanyl causes reduced feelings of pain a sense of euphoria and relaxation. Side effects include nausea, vomiting, constipation, altered heart rate, slowed breathing rate, confusion, hallucinations, weakness, sweating, itchy skin constricted pupils and seizures. It is so powerful that the risk of overdosing on this drug if very high, with death usually caused as a result of respiratory failure.

Sources:

www.drugabuse.com

www.drugabuse.gov

www.talktofrank.com

www.telegraph.co.uk

Toxic Grenfell

By Nikolina Kovacevic

After the tragedy of the devastating Grenfell Tower blaze which took place on 14th June 2017 and greatly affected the lives of many, researchers have recently discovered its catastrophic repercussions on the surrounding area.

Professor Ana Stec, an expert in fire chemistry and toxicology at the University of Lancashire, launched an investigation, in late 2017, into the effects of the Grenfell fire, which discovered extremely high concentrations of carcinogens within the soil surrounding the site of the former block of homes. One of the carcinogens discovered is hydrogen cyanide, a toxic gas which can lead to death.

Hydrogen cyanide affects the body by blocking its ability to use oxygen. It interferes with the enzyme known as **cytochrome oxidase**, which transfers oxygen from the blood to cells and tissues. In essence, the toxic gas suffocates your cells, preventing oxygen from reaching them and leading to reduced respiration.

She raised the concern that these carcinogens may have caused long term health problems to those who were situated at or close to the fire. She also mentioned that these effects could still be ongoing and have the possibility of affecting citizens who live and work in the local area. Stec suggested that the so-called “Grenfell cough” reported by survivors after the fire “seems indicative of elevated levels of atmospheric contaminants”, which backs up her findings.

Sources:

www.theguardian.com/uk-news/2018/oct/12/toxins-found-in-grenfell-tower-soil-study-finds

www.articles.latimes.com/1992-04-11/news/mn-180_1_hydrogen-cyanide-gas

ELEMENT FACT FILES

By Giorgia Merighi

Iridium

Transition metal

- Atomic number: 77
- Mass number: 192.22
- Density: 22.56 g/cm^3 (it is the 2nd densest element after osmium)
- Melting point: 2446°C
- Boiling point: 4428°C
- Discovered: 1803 by Smithson Tennant
- Origin of the name: Latin word 'iris' meaning rainbow
- Words used to describe it: hard, brittle, lustrous, dense

Why is it interesting?

- Iridium is the most corrosion resistant element currently known – it is unaffected by air, water, acids and bases, thus making it extremely useful in industries which require high corrosion resistance at high temperatures. e.g. Iridium is used in spark plugs in car engines
- It is also used in special alloys (a mixture of two or more metals melted together) formed with osmium, which are used for fountain pen tips and compass bearing.
- Iridium is one of the rarest elements on earth, only a very thin layer of it exists in the Earth's crust (the rest mainly in the Earth's core), thus making it a valuable metal.
- Scientists speculate that it is able to be found in the crust because of a large meteor or asteroid hitting Earth, thus depositing a dust cloud of iridium all over the world, potentially the same meteor that wiped out the dinosaurs 66 million years ago.

Mercury

Transition metal

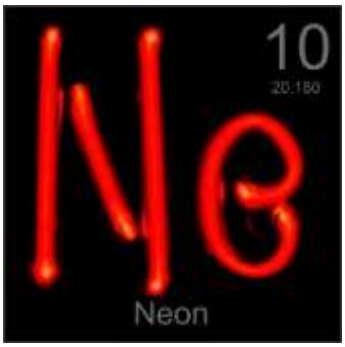
- Atomic number: 80
- Mass number: 200.59
- Density: 13.53 g/cm^3
- Melting point: -38.8°C
- Boiling point: 356.6°C
- Discovered: approx. 1500BC
- Origin of the name: Named after the planet Mercury
- Words used to describe it: shiny, silvery, liquid metal, 'quicksilver'

Why is it interesting?

- Mercury is the only metal that is a liquid at standard temperature and pressure. It forms rounded beads of liquid, giving it an unusual appearance. N.B. Bromine (a halogen) is the only other liquid element under standard conditions.
- Mercury and all its compounds are highly toxic, however throughout history it was used freely, for example, by Palaeolithic painters 30,000 years ago to decorate caves, and by Romans in cosmetics.
- Today, mercury is used in thermometers, fluorescent lamps, float valves, to make liquid mirrors, and in the production of other chemicals. However, its usage is strictly controlled.
- It is a very rare element in the Earth's crust, accounting for only 0.08 parts per million (ppm) and it is usually found combined with other elements.

Neon

Noble gas



- Atomic number: 10
- Mass number: 20.18
- Density: 0.000825 g/cm^3
- Melting point: -248.6°C
- Boiling point: -246.0°C
- Discovered: 1898 by Sir William Ramsay and Morris Travers
- Origin of the name: Greek word 'neos' meaning new
- Words used to describe it: colourless, odourless, unreactive

Why is it interesting?

- Neon is mainly used in making the famous 'neon signs' for advertising.
- However, N.B. only the red neon signs actually contain pure neon (which glows a reddish-orange in a vacuum discharge tube). Others contain different gases to give different colours.
- It also has many other uses such as to make diving equipment, lasers, and lightning arresters.
- Neon is also an important cryogenic refrigerant in liquid form. It has more than 40 times the refrigerating capacity of liquid helium, and more than 3 times that of liquid hydrogen.
- Neon is the fifth most abundant element in the universe, and is present in large quantities in the Earth's atmosphere, making it an easily accessible element.

Sources:
www.rsc.org
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PHYSICS

NASA'S Journey to the Sun

By Caroline Swenson

This summer NASA began the historical odyssey to one day touch the 5,726-degree sun surface. The Parker Solar Probe (PSP) was launched on August 12th from the launch complex 37 in Cape Canaveral. It is humanity's first-ever mission to the Sun's atmosphere- the corona (the plasma that surrounds the sun). It will directly explore the solar processes which are essential to the understanding of the sun's nature and origins- solving some of the most stubbornly tenacious mysteries about the centre of our solar system. The probe will have a mission duration of 7 years, where it will circle around the sun 24 times, travelling as the fastest man-made object with a speed of up to 690,000 km/h. This mission marks the first voyage to reach a star that will increase our understanding of our universe; it will accomplish this task by settings its sight on the corona to resolve long-standing, foundational questions regarding the sun.

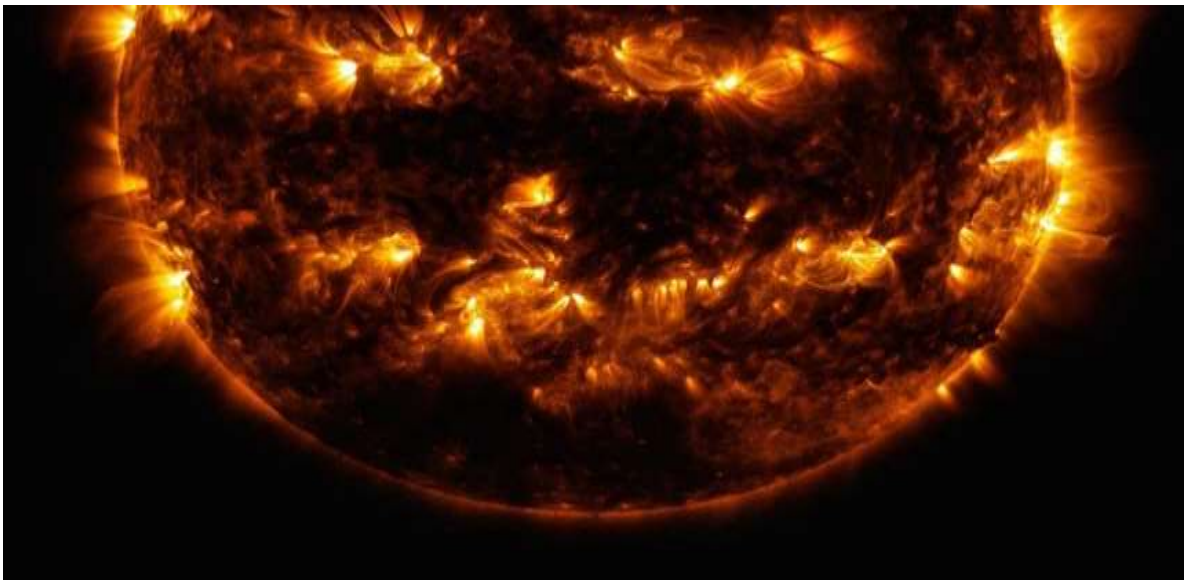
This probe will be the first to fly in low solar coronal orbit, enabling us to view the undercurrents of the Sun's coronal plasma (the firey-looking stuff) and magnetic field. Its trajectory requires a high launch energy, so that it will be launched on a heavy launch vehicle with a solid rocket motor. The trajectory design uses many gravity assists at Venus in order to decrease the orbital perihelion (point in the orbit that is closest to the sun) and deceleration. This orbit will also result in a heliocentric (sun-centered) record at the perihelion. As like any other object in orbit, it will accelerate due to gravity as it nears the perihelion (the point in an orbit where the celestial body is closest to the sun) and subsequently slow down as it reaches the aphelion (point of orbit where the body is farthest from the sun). When it is nearest to the sun, the radiation environment is predicted to affect the spacecraft's material and electrical components.

Consequently, the orbit will be very elliptical (oval-shaped) with short durations closest to the sun. As it immerses itself in the scorching atmosphere of the sun, the incident incoming solar radiation present at the perihelion is 475 times greater than in Earth orbit. It thus requires the protection of its 1,300-degree Celsius 4.5-inch carbon-composite heat shield. The heat shield is also hexagonal, between the satellite and the sun- covered with a white reflective alumina surface to minimize absorption. The shield was aligned in this way between the spacecraft and the sun to protect the probe from the intensity. Otherwise, it would become inoperative within about 30 seconds. The power obtained for this system is transferred using photovoltaic array solar panels which lie behind the shadow shield as it approaches the sun, maximizing the exposure. It is clear that this an extremely autonomous spacecraft.

The probe will perform four main studies to research the following: magnetic fields, plasma, and energetic particles, and image the solar wind. It is crucial to study the sun for the following reasons: it is the source of light and heat for the earth, the centre of our solar system, and the source of the mighty solar wind. Solar wind shakes the earth's magnetic field, pumping energy into radiation belts, Solar wind fills up much of the solar system, and, as we send more people into space, we must understand this environment. The scientific phase of the mission will occur when the spacecraft is closest to the sun- the most hazardous region of intense heat and solar radiation. It will aim to achieve a variety of goals: to trace the flow of energy which heats the corona and accelerates the solar wind, to determine the structure and dynamics of the magnetic fields at the solar wind sources, and to associate which mechanisms accelerate and transport the energetic particles (high-energy particles coming from the sun) and to investigate the electromagnetic field present. It will also, and the most exciting aim- make direct

measurements using five plasma voltage sensors and a search-coil magnetometer to measure the electromagnetic fields, electron temperature, and plasma density. The quantities of electrons, protons and helium ions, along with the properties of their density, velocity, and temperature, will be found through this probe.

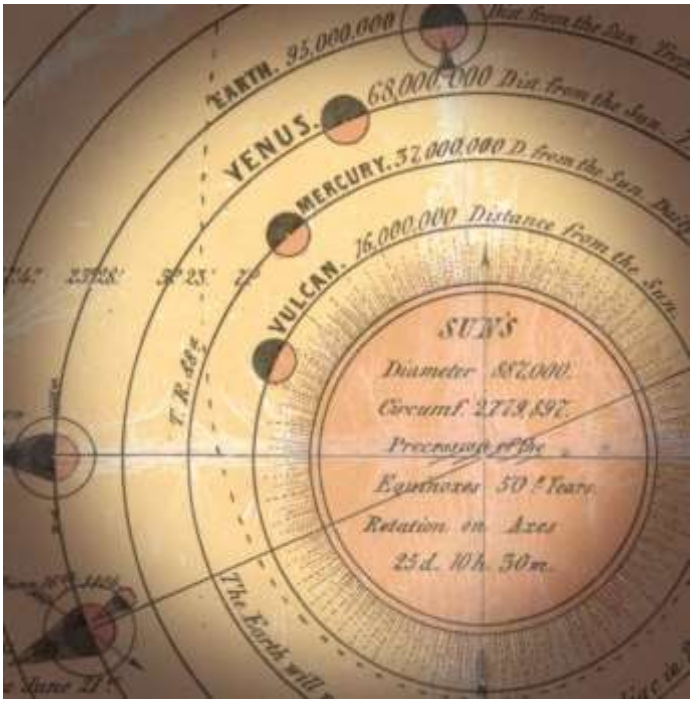
This research will explain the basis of the scorching corona (300 times hotter than the Sun's surface alone), the driving force of the supersonic solar wind, the constant stream of solar material holding an entire solar system in orbit, and the acceleration of solar energetic particles which can reach half the speed of light. These mission findings will aid researchers' forecasts of space weather events- which have the potential to damage satellites and harm astronauts in orbit and overwhelm power grids. Scientists have sought answers to these questions for over 60 years, and finally, with the innovative developments of thermal engineering, the sun probe has been made. This shift from fantasy to fact is summed up by NASA's associate administrator Thomas Zurbuchen, who remarked that they "accomplished something that decades ago lived solely in the realm of science fiction."



Sources:
www.nasa.com
www.space.com

The planet Vulcan 1859-1919

By Laurence Dare



It took many years of scientific method to understand the motion of the planets in the solar system. Originally, in anthropocentric fashion, it was believed that the Earth lay at the centre of the solar system, with the planets and stars moving around it. This is clearly a tempting hypothesis in that we cannot feel the Earth moving and the sun appears to rise every morning and set every evening. It also fitted in with nearly all religious philosophies. Up until the 16th century, the 'heavens' were thought to consist of eight bodies: Mercury, Venus, The Earth, The Moon, Mars and Jupiter.

Copernicus, early in the 16th century published his famous, and at the time heretical, manuscript 'Dē revolutionibus orbium coelestium'. He used seven clearly stated axioms plus the known movement of the planets to deduce that the sun had to lie at the centre of the solar system. One of these was known as the retrograde motion of Mars, where Mars appeared to go backwards for a part of its orbit, as observed from the Earth. This backward motion can be clearly explained when you think of both Mars and Earth going around the sun in concentric loops, with the Earth inside Mars and orbiting with a greater angular velocity (equivalent to a shorter year). This idea of using a set of axioms and repeatedly observable phenomena is the basis of the philosophy of science, and it is quite remarkable to see this being used so early in the 16th century.

Galileo Galilei (1564-1642) used his newly invented telescope to observe the phases of Venus, which appeared to be very similar to the moon. This was pretty much the death knell for the geocentric view of the solar system as, according to Ptolemy, it was impossible for any of the planets' orbits to intersect the spherical shell carrying the Sun.

Despite the brilliance and perseverance of Copernicus, Galileo and many other less well known scientists, all that had been done up until the mid 17th century was to describe the motion of the objects in the solar system, not to explain them. In 1687, Isaac Newton (1642-1727) published his 'Philosophiae Naturalis Principia Mathematica' in which he proposed his three laws of motion and the fact that gravitational force between two masses was directly proportional to the product of the two masses and inversely proportional to the square of the distance between them. These remarkable propositions, together with the newly discovered calculus (independently by Leibniz and Newton) were able to explain over 99% of the motion in the universe, including subtleties only detected later such as the precession of planetary orbits.

For many years Uranus's orbit was not thought to obey Newton's laws. The astronomer and mathematician John Couch Adams (1819-1892) observed the irregularities of Uranus's orbit and showed mathematically that they could be explained by an invisible planet (as the reflections of the sun's light were too dim to be observed using then telescopes) orbiting at the outer edges of the solar system. Remarkably, given that this was a long time before electronic calculators or computers, he predicted the exact size and orbit of the planet, which was to be named Neptune. Although some had observed Neptune before, the first confirmed observation was in 1846 by Johann Gottfried Galle, in exactly the expected place.

Given this great success, it was hardly surprising that when Mercury's orbit did not precisely conform to that predicted by Newton's laws, the deviation was ascribed to the existence of another planet. In this case the French mathematician Urbain Le Verrier proposed, in 1859, that the deviation in Mercury's perihelion precession (how closely it approaches the sun on each orbit) could be explained by a small planet orbiting inside mercury. He named this planet 'Vulcan' after the Roman god of fire, apt for a planet so close to the sun.

Thus, the hunt was on to discover Vulcan! Due to the brightness of the sun, the best chance of observing such a planet is during a solar eclipse, when it should appear as a bright little star reflecting a scintilla of sunlight on to the Earth. The interesting thing about the hunt for Vulcan was how many eminent scientists claimed to have seen it, including Le Verrier himself. These mistaken sightings were caused by two factors: being overly respectful of the famous and confirmation bias. According to Psychology Today, confirmation bias is 'when people would like a certain idea/concept to be true, they end up believing it to be true. They are motivated by wishful thinking. This error leads the individual to stop gathering information when the evidence gathered so far confirms the views (prejudices) one would like to be true.' It is a type of cognitive bias. Scientists need to be wary of trying to prove something to be true and, equally, of accepting that something is true merely because someone very famous or very bright claims it to be true. This can be far harder than it appears!

The hunt for Vulcan was finally put to rest when, anecdotally, Einstein was observing two workers on a building site and wondered what would happen if they fell off. He realised that they would not feel the pull of gravitational force as they accelerated. This makes it 'different' qualitatively from the other forces. He then hypothesised that you could not tell the difference between being in a box accelerating at 9.81 m/s2 in space or standing on the Earth with the same gravitational field strength. If light behaved the same way, it would have to be bent by gravitational force and, further, were that to be the case, gravitational force could not be a 'force' like the other forces, as forces cause masses to accelerate, and photons (light) have no mass.

Einstein, a little like Copernicus 400 years earlier, and just as heretically to the then deeply held scientific beliefs, had the courage to believe in the above axioms and to develop them to their logical conclusions. The fundamental idea of his General Theory of Relativity is that, instead of gravity being a force, it causes space-time to curve and that an object accelerating due to gravitational force is effectively moving at a constant velocity on the curved surface of space-time. Of course, we cannot see the curvature so, from our frame of reference, an object appears to accelerate. Simply put, mass causes the curvature of space-time and curved space-time causes masses to move. This elegant yet bizarre sounding idea takes a lot of mathematics to prove and depends crucially on a mathematician called Georg Riemann (1826-1866). Riemann had extended the geometry of finding geodesics (shortest distance between two points on a curved surface) to n dimensional surfaces. This very arcane field of study fitted

perfectly with Einstein's notion of curved four-dimensional space-time and so his great theory was born.

Einstein's General Theory only makes a significant difference where masses are great compared with separations, and this is true of Mercury, orbiting relatively closely to our massive sun. The 7% of Mercury's precession not adequately explained by Newton was perfectly explained by Einstein and the motion of the heavenly spheres could once again all be accounted for by physics and mathematics, without recourse to a fictional planet.

Sources:

Inspired by: The Hunt for Vulcan, George Levenson 2015

Video on YouTube: Dr PhysicsA 'Einstein's Field Equations for Beginners'

https://www.physicsoftheuniverse.com/dates.html

TECHNOLOGY

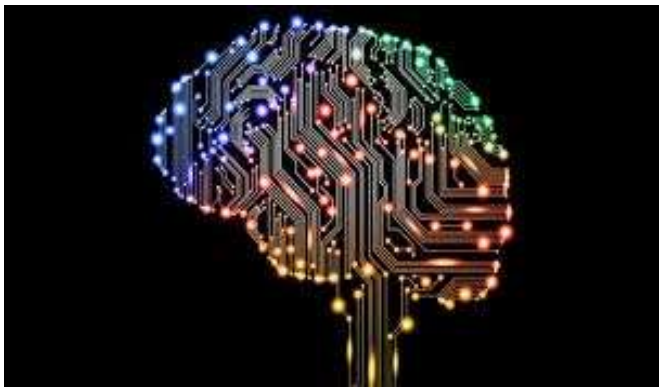
AI- what is it and where did it all begin?

By Saffron Zainchkovskaya

Artificial Intelligence - defined as “the theory and development of computer systems (to be) able to perform tasks normally requiring human intelligence …” is something that is considered as a ‘hot topic’ in today’s news.

The theory of AI however has existed for many years, with Alan Turing proposing the Turing test in a 1950s paper titled “Computing Machinery and Intelligence”. The paper revolved around the question of “can computers think?”- and to answer this question Turing proposed the Turing test which was designed to test the intelligence level of a machine compared to that of a human. The test itself is rather simple- a human judge would have interactions with two ‘players’ - one of whom is a computer, whereas the other is a human. The judge would interrogate both of the players with the aim of deciphering which of the two is the computer. If the judge is unable to correctly identify the computer from the human then the Turing test has been passed. Although there is some debate about this, the Turing test was declared as passed at an event organized at the University of Reading where a computer program – ‘Eugene Goostman, a 13 year old Ukranian boy’ - was judged to be human. The emphasis on the age and country of the ‘boy’ was to allow the judge to permit the language to be less advanced, therefore making it easier for the test to be passed.

Even though the Turing test has been debatably passed, Artificial Intelligence still has a long way to go, with exciting advances being made almost daily. This topic in Computer Science is exciting. Despite this, it is important to analyse the ethical and moral considerations when developing an intelligent program or machinery.



Sources: http://kryten.mm.rpi.edu/SEP/index8.html#1

By Saffron Zainchkovskaya

5

Word ladder

Convert the word LISP into the word JAVA in 5 steps or less. You must only change one letter of the word on each step. On every step you should have created a word in the english dictionary.

L I S P

- - - -

- - - -

- - - -

- - - -

J A V A

6

Bit ladder

Convert the binary word 000 into the binary word 100 in 7 steps or less. You must only change one bit of the word on each step. You may only use 1s and 0s.

0 0 0

- - -

- - -

- - -

- - -

- - -

- - -

1 0 0

10

Extreme logical thinking: eating at Quonk

A group of friends, two women (Alice and Babs), and two men (Zach and Yabu), like to pair up to go out on dates to cool restaurants. There are four combinations they date in (Alice-Zach, Alice-Yabu, Babs-Zach and Babs-Yabu).The favourite restaurant of one of the men and one of the women is a place called Quonk. However if those two eat together they always try new restaurants as do the other pair if together. Therefore when exactly one, and only one, of the particular man and woman in question is on a date they eat at Quonk. When Alice goes out with Zach they go to Quonk.

Which, if any, other pair from those below eat at Quonk:

1) Alice and Yabu,

2) Babs and Zach,

3) Babs and Yabu, or

4) none of the other pairs eat at Quonk?

18

The swap puzzle

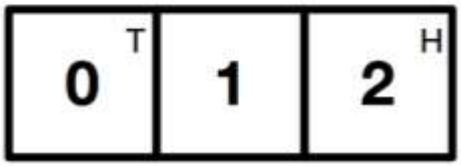
Place small coins heads up on the squares marked H and tails up on the squares marked T.

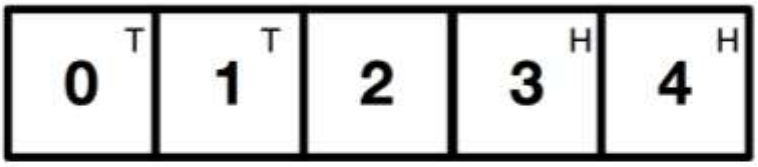
Swap the positions of the Heads for the Tails in as few moves as possible.

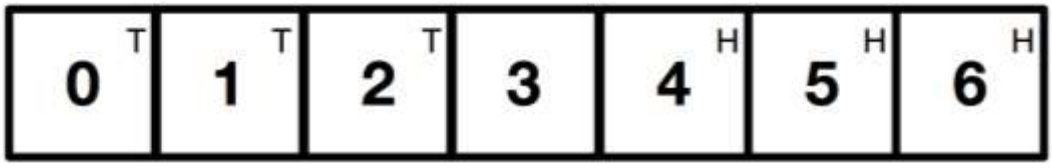
There are two ways to move a piece:

1. Move left or right to an adjacent empty square
2. Jump over a single adjacent piece into an empty space.

There are three increasingly larger boards that get harder. Complete the first in 3 moves, the second in 8 moves and the third in 15 moves.



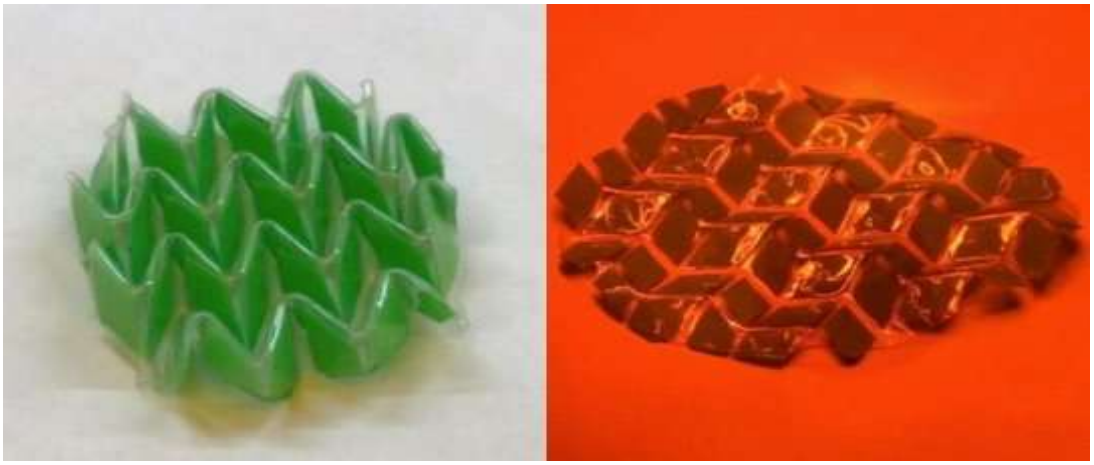




ENGINEERING

Shape-shifting material can morph, reverse itself using heat, light

By Nour Akhrass



University of Colorado Boulder engineers designed a new material that can transform into complex and pre-programmed shapes using light and temperature. The material can morph from a square peg to fit into a round hole before being converted back to its original form.

The shape-shifting material could be used for manufacturing, robotics, biomedical devices and artificial muscles. Exposing this material to light causes it to vibrate back and forth, making independent and new shapes.

Previously, shape-shifting materials were attempted using physical mechanisms, changing the object's size, shape or texture using programmable stimuli. This has proven to be difficult as materials have been limited in size and it is difficult for them to reverse back into their original states. The new material is susceptible to dynamic change through heat and light using liquid crystal elastomers (technology underlying television displays), allowing the material to undergo programmable two-way transformations.

The engineers installed a light-activation trigger to the liquid crystal elastomer that can influence the molecular alignment of the material by exposing it to different wavelengths of light. The material contains a trigger that remains inactive until exposed to a heat stimulus, resulting in shape-shifting. This shape-shifting property can be used for a myriad of applications, especially for biomedical devices that could become more adaptable and flexible than ever.

Sources:
https://www.colorado.edu/today/2018/08/24/shape-shifting-material-can-morph-reverse-itself-using-heat-light

Humans help robots learn tasks

By Nour Akhrass

People will soon be able to interact with robots to help them carry out basic tasks using only a smartphone and a browser.

At Stanford University, a team of researchers have developed two frameworks that, combined, could make it easier and faster to teach robots basic skills. The RoboTurk framework enables people to control the robot's arms in real time with a smartphone and a browser, by showing robots how to carry out simple tasks such as picking up objects. SURREAL allows the robots to learn many experiences simultaneously by running multiple experiences at once and thus speeding up the learning process.

On October 29th, the group presented the project at a conference on robot learning in Zurich. Yuke Zhu, a PhD student in Computer Science and a member of the team, showed how the system worked simply by waving his phone through the air after opening an app on his iPhone. He controlled the robot's arm to pick up objects and placing them into the bin with the correct label. Their demonstration, however, was not perfect as when Zhu pressed hard on his screen, the robot released its grip and the object fell onto the table.

Using a handheld device, Ajay Mandelkar, Jim Fan and Yuke Zhu use their software to control a robot arm.

“With RoboTurk and SURREAL, we can push the boundary of what robots can do by combining lots of data collected by humans and coupling that with large-scale reinforcement learning," said Ajay Mandlekar, a member of the team that developed the framework.

These trials have provided the foundation knowledge to kickstart a robot’s learning. The team hopes that soon robots will be an important part of everyday life in the future, helping with a myriad of tasks that will benefit humans.

Sources:

https://www.sciencedaily.com/releases/2018/10/181026143359.htm

A Letter from University - 09/10/18

By Safa Ghanem

Dear Francis Holland,

Before I delve into what the world of engineering at university is like, let me first explain to you what engineering as a degree actually entails. Engineering is the study of technology and science that focuses on the design of engines, machines, structures and electrical systems. Engineering is deeply rooted in mathematical principles and is the perfect option for anyone who enjoys maths and physics at school. If you combine the practicals and experiments from your physics lessons with the pure and mechanics maths modules - this is the closest way to describe the first year of engineering at university.

Mechanical engineering (what I am currently studying) brings in the core principles of engineering and applies them to the design and manufacturing of mechanical products like engines and heavy machinery. It is by far the broadest discipline, allowing students to work in a large range of different career opportunities. Mechanical engineers can be seen working for motor companies designing and improving combustion engines, in manufacturing plants improving processes and even working in the manufacturing of heavy equipment like sea vessels and tanks. Personally, I hope to specialise into biomedical engineering. This is a field which combines the applications of engineering to help the medical world. As you can see with a base degree like Mechanical engineering you have a huge range of career options

Before actually arriving at university I probably had the same preconception about what studying engineering would be like as you all do now reading this letter. Whenever people found out what I would be reading at university the first thing they would respond with was ‘why would you do that to yourself’ or they would proceed to tell me how I would have maths and physics lectures 9-to-5, every day, and then have to lock myself in my room for hours doing even more work. Thankfully when I got here the reality was a completely different story. To my relief rather than having five days of back to back lectures, a lot of engineering is taught through a series of seminars, labs and workshops. In our first few weeks we are given a series of lab training sessions where we learn to safely use the equipment. As the year progresses we are then to use the skills we are taught to actually manufacture our own projects. This involves designing the product on

a design software called Solidworks, for example, and then taking this digital design and actually making the physical product in the workshop using industrial machines including milling machines, lathes, morticers and many more. Another misconception many people have about engineering is that it consists of purely maths and physics. However, the creative students among you will be pleased to hear that a huge aspect of engineering is design and creativity. So much so that we have 3 hours of drawing lessons a week (1/8 of our total contact time a week). The first drawing seminar involved drawing vertical and horizontal lines without a ruler and perfecting out free hand circles. As the weeks went on we then applied these skills to sketching small component parts free hand in detail. As engineering is a pretty full on degree these drawing lessons act as much appreciated relief from all the maths. I am someone who struggled with art at GCSE and, thankfully. the tasks set for us don't require any actual artistic talent. It just takes practice to pick up the skills needed for technical drawings.

Personally, when applying to my course I think my biggest concerns were not knowing enough about specifics in engineering (like the inner working of a combustion engine) and not being able to programme. Thankfully, when I arrived, the degree is set-up so you that don't need any prior knowledge in the field. Everything is taught from ground zero, from programming to the maths and physics concepts. Having done further maths at A-Level, I found myself a term ahead of the maths module which proved extremely convenient. So, as long as you have a solid foundation in (single) maths and physics and enjoy them, then I'd say you're the perfect candidate for an engineering degree.

MATHEMATICS

A Prime Time to Discover a New Number

By Karina Vasiliades

After 14 long years of computations, on 26th December 2017, Johnathan Pace, an electrical engineer from Tennessee, finally discovered the largest prime number known to man: M77232917.

This prime, colloquially known as M77232917, is over 23 million digits long and has been classified as a Mersenne Prime, a prime number that is one less than a power of two ($M = 2^n - 1$, with n being an integer). It is the sixteenth largest prime number to have been discovered since 1996, when the Great Internet Mersenne Prime Search (GIMPS), a collaborative computer search project kicked off. To put the size of the number into perspective, according to a GIMPS statement:

> 'It's huge!! Big enough to fill an entire shelf of books totaling 9,000 pages! If every second you were to write five digits to an inch then 54 days later you'd have a number stretching over 73 miles (118 kilometers) – almost 3 miles (5 kilometers) longer than the previous record prime.'

Pace described his latest discovery as "a museum piece as opposed to something that industry would use" because of its intricate beauty and uniqueness. As a result of this monumental mathematical discovery, Pace received $3,000 (£2,211) as part of the Mersenne Prime Search (GIMPS) research discovery award.

The next prime number is said to contain over 100 million digits, an astounding magnitude for a number whose only factors are one and itself. The person who discovers this number will be rewarded $150,000 for their outstanding achievement in mathematical discovery.

Sources:
www.independent.co.uk/news/science/prime-numbers-largest-ever-found-23-million-digits-gimps-a8144201.html
https://earthsky.org/human-world/largest-prime-number-discovered-mersenne-primes

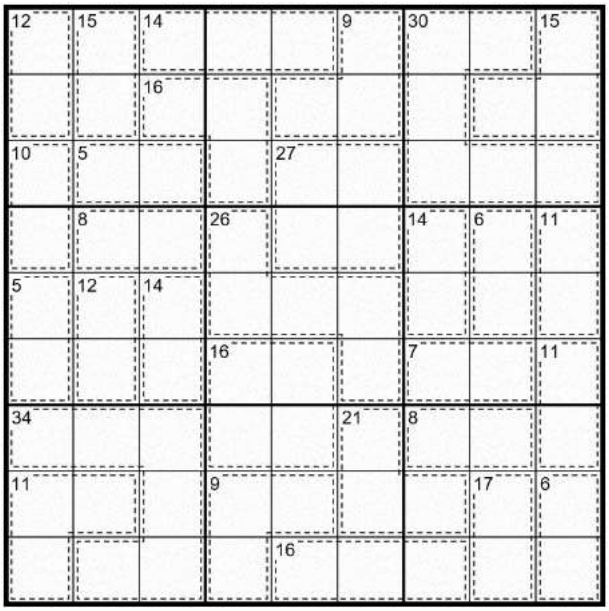
PUZZLES – Have a go! (answers can be found at the back)

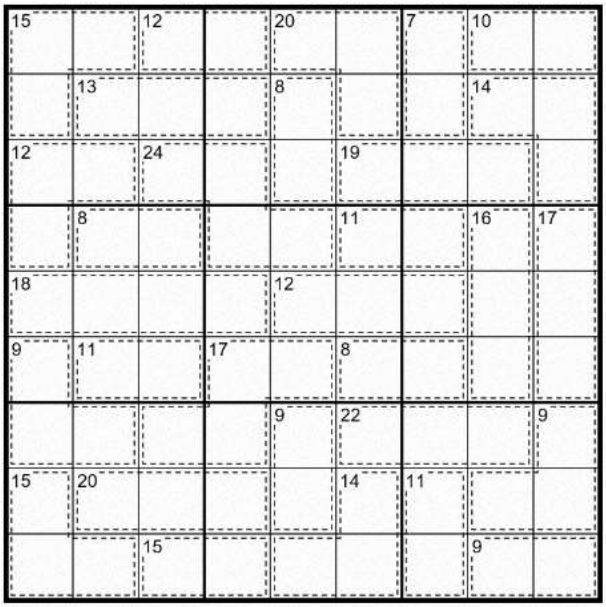
By Joelle Hakim

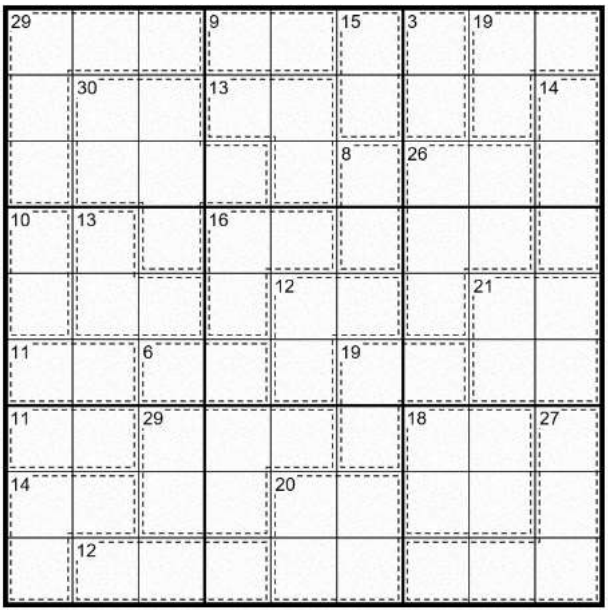
KILLER SUDOKU:

Similar to Sudoku, the aim of Killer Sudoku is to fill each column, row and smaller 3x3 grid, with the numbers from 1 to 9 (only once).

However, the step up is that there are extra sections called ‘cages’ (set out by the dotted lines) where the numbers in the cage should add up to the number in its top left-hand corner and again the numbers should not be repeated.







ONE – TO – FIVE:

The aim is to fill up the squares so that each row and column should contain the numbers from 1 to 5. In addition you will have to follow the given number(s) and symbols to figure out if they are > (greater than) or < (smaller than) the number next to it.

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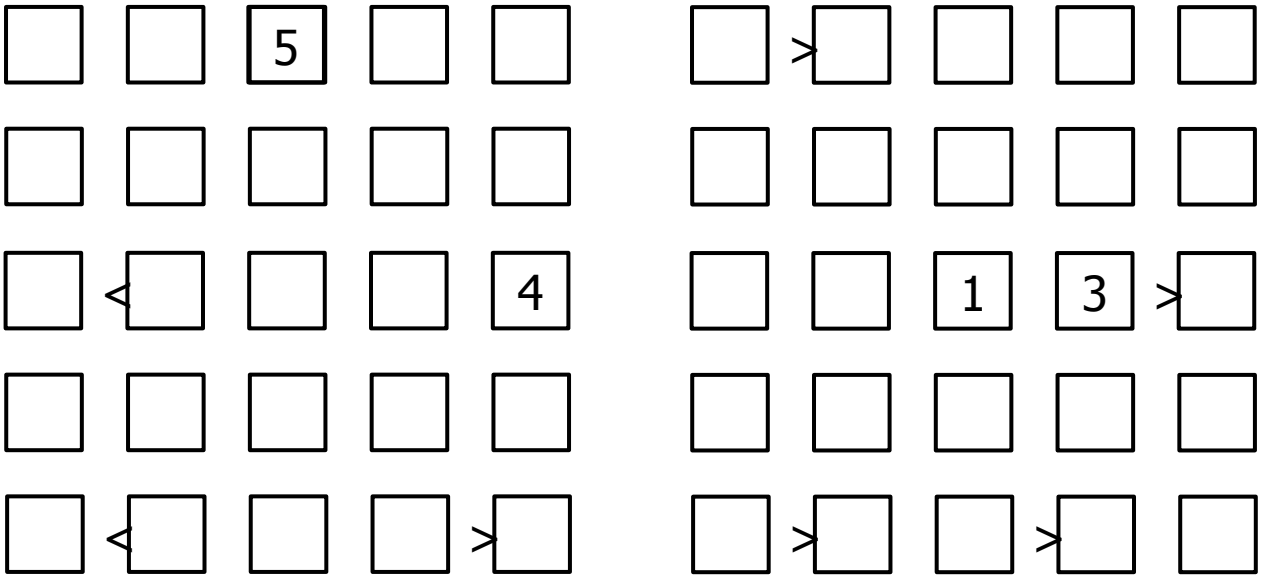
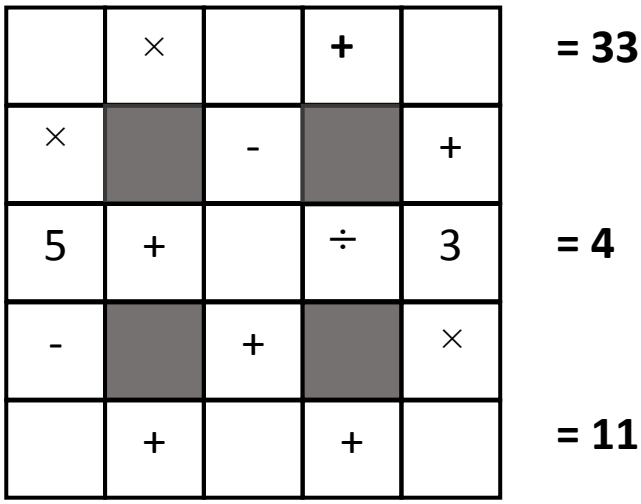
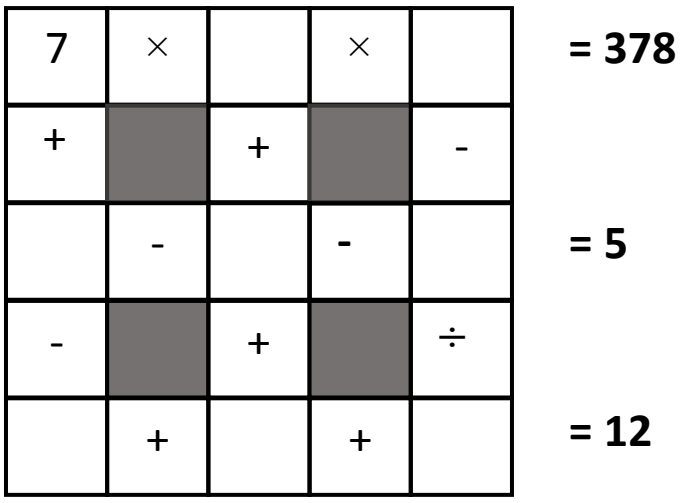


SOLVE THE GRID:

Fill in all the squares with numbers 1 to 9 to make the sums in the grid correct.

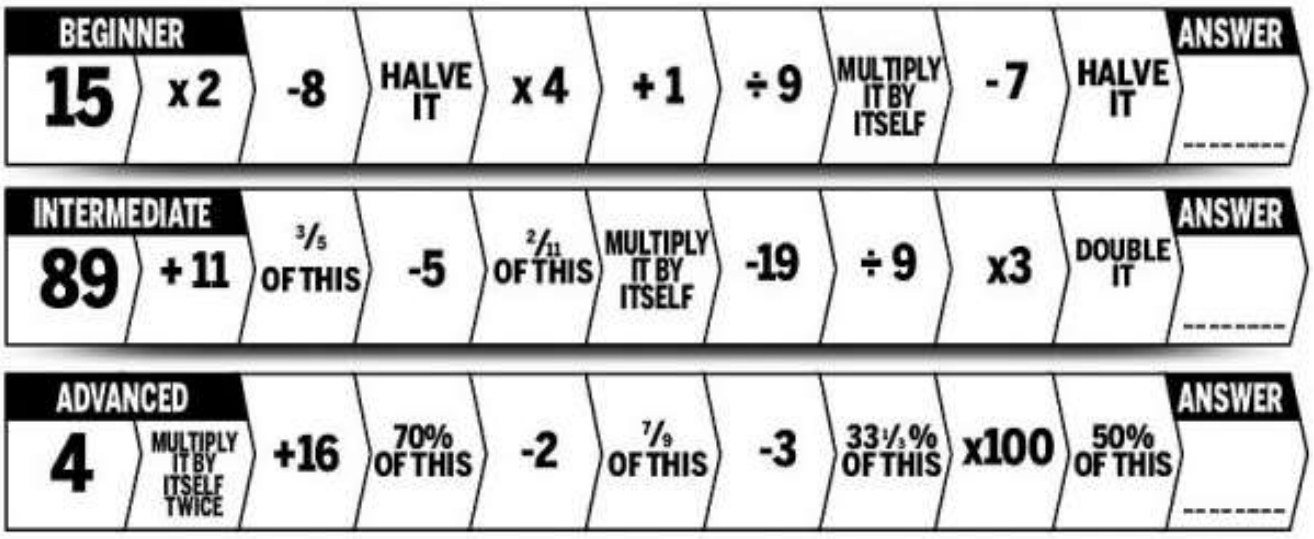


	×		+		= 33
×		-		+	
5	+		÷	3	= 4
-		+		×	
	+		+		= 11
=		=		=	
29		5		24	



7	×		×		= 378
+		+		-	
	-		-		= 5
-		+		÷	
	+		+		= 12
=		=		=	
10		11		2	

MENTAL MATHS:



STEMM TALKS

Gut feelings: gut bacteria, cravings, chocolate and poo. 11/10/18

Dr Emily Grossman, Science Broadcaster, writer & educator

Dr Grossman spoke candidly about her journey as a woman to being in a STEMM career and imparted great advice to everyone present, including that there is no one type of scientist in a field as broad as science.

She tested a number of scientific theories, including whether gut bacteria causes colic in babies; whether obesity is contagious, and whether the flu causes us to become more sociable, as well as exploring whether we are being controlled by microorganisms. Her engaging talk definitely brought up a lot of interesting points!

STEM 08/11/18

Dr Mark Richards, Imperial College

Dr Richards greatly inspired his audience by discussing STEM pathways and the stereotypes of scientists. He highlighted that there are many diverse opportunities that science and STEM subjects can lead to, for example, remixing tracks and modelling -
not just a job as a researcher.

Moreover, he discussed the creativity, innovation and enterprise that is involved in STEM, such as his own passion for music, which allowed him to develop skills that he was able to translate to the study of waves in his current research. In this way, he broadened everyone's perspectives on the field and gave us a new insight into its relevance today.

BBC Science Live 20/11/18

By Saffron Zainchkovskaya

On Tuesday 20 November 2018 Mr Dyson, Joelle and myself travelled to the BBC RADIO 1 CLICK LIVE event, where we were exposed to all the new and upcoming technology.

The event was thrilling as we were able to see the way in which topics that we are currently studying in computer science were brought to life, in a more exciting medium such as robotics. The evening started off by exploring the world of AR (augmented reality) where we were handed a headset and were able to witness snippets of a new genre of plays which involved both AR and actors. What made the experience more surreal was that there was a layer of a pre-recorded audience, so the image that we saw through the headset was positioned from the same angle as we were sitting, and if I was to turn my head to the left I was able to see a pre-recorded audience member instead of the person sitting next to me (Joelle). The nature of the play allowed the audience to interact not only with the graphics seen through the headset, but also with the actors. The next talk that was given was on a startup company that worked on cheap and accessible “dancing robots”, that could be used as an educational tool to teach children and teenagers how to program, allowing them to explore a new coding language and the way that software interacted with hardware.

Another target audience for these robots was the general public, as these robots genuinely were rather cool. One would be able to use pre programmed instruction sets to make a robot wave at them or dance a choreographed routine to Beyoncé’s ‘Single Ladies’. It was extraordinary to be able to see the different stages of development that the company went through in order to produce and choreograph a set of twenty robots, from the analysis stage to the development of the robots, and the choreography process that involved both coding and animation.

The next talk that was given was similar to the dancing robots and focused on the way in which robots could be used in an artistic performance, as roughly ten different drones followed a pre-programmed route with flashing lights as the presenter danced around them. What made this performance so breathtaking was the incredible amount of precision involved in the choreography, as the presenter and ten flying drones danced around each other so perfectly without crashing. The presenter went on to explain the way in which these robots were programmed to avoid each other, and how they followed a path which they tracked by a number of different sensors and cameras on the body.

As artificial intelligence is a “hot topic” in today’s news there was bound to be at least one presentation surrounding it. However, we were able to witness a new and refreshing take on AI from the point of view of an entrepreneur who was using AI to start up his extraordinary business. His initial idea was to develop a program that would

allow anyone, anywhere to create a website/ app/ program with ease. This would be done by a user selecting the functionality, looks and purpose of their application and using pre-loaded building blocks of code to create the final result. This idea is fascinating as it will allow for anyone to develop their idea past the first stage, as one wouldn't need years of experience in tech to be able to create a technology based company. The company is also more efficient than programmers, as the building blocks can be woven together in a couple of hours, whereas it would take days to create the same effect with a human sitting behind the screen. As you can imagine this talk did raise a few questions, as now it could be seen that humans are taken out of the equation for the development and testing of code. This made many people feel uncomfortable in the way in which AI is progressing. However it was reassuring to hear that the whole process always needs creative people who would be given the opportunity to create a company with this development.

Overall the experience was amazing as it introduced us to all the new technology that is being created now, allowing myself and Joelle to see the opportunities that would be available to us in the near future. All the talks given incorporated the theme of creativity and how it could be used to produce such extraordinary creations with computers.

From left: Saffron Zainchkovskaya, Joelle Hakim, Caroline Swenson, Sandrena Steeds

25th International Space Competition NASA

Four girls in Upper Sixth travelled to Cape Canaveral over the summer to compete in the final international round of the International Space Settlement Design Competition, having completed various stages in London during the year, leading up to the final at NASA. The competition has been running since 1994 and has been held at NASA's Kennedy Space Centre since 1996, testing the participants' design, logistical and scientific skills.

It uses a fictional organization called the Foundation Society to create a futuristic setting for the competition. From there, four fictional companies are created with sizes varying from few to dozens, depending on the attendance, and they must compete for a "contract" with the Foundation Society to build a lunar settlement – a perfect simulation of the engineering industry.

Competitors had to present a slideshow presentation of their project, including illustrations, diagrams, calculations and references. Moreover, they were limited to using plausible extensions of current technology in their proposals (i.e. no "cold fusion" or "space elevators"). Having produced a high quality project, Saffron Zainchkovskaya, Joelle Hakim, Caroline Swenson and Sandrena Steeds – 'Grumbo Aerospace' – thoroughly impressed the judges and won the whole competition outright.

"The week spent at NASA has been the most amazing one of my life. I have learnt so much, from teamwork to my love and passion for my subject. This competition has allowed me to push myself and apply my previous knowledge from school to a more exciting and challenging medium, and I hope to now inspire someone like it has inspired me." *Saffron Zainchkovskaya*

ALASKOL 2043

GRUMBO AEROSPACE

FURTHER READING

BIOLOGY

- The Third Chimpanzee: On the Evolution and the Future of the Human Animal
  By Jared Diamond
- Guns, Germs & Steel: A short history of everybody for the last 13,000 years
  By Jared Diamond
- A Crack in Creation: The New Power to Control Evolution
  By Jennifer Doudna and Samuel H. Sternberg
- Being Mortal: Illness, Medicine and What Matters in the End
  By Atul Gawande

CHEMISTRY

- The Periodic Table: A Field Guide to the Elements
  By Paul Parsons
- Elements of Murder: A History of Poison
  By John Emsley
- What is Chemistry?
  By Peter Atkins
- Vanity, Vitality and Virility – The science behind the products you love to buy
  By John Emsley
- How to Give Up Plastic
  By Will McCallum

PHYSICS

- The Quantum Universe
  By Brian Cox & Jeff Forshaw
- Newton
  By Peter Ackroyd
- The Hunt for Vulcan
  By Thomas Leverson
- Brief Answers to the Big Questions
  By Stephen Hawking

TECHNOLOGY

- Digital Human: The Fourth Revolution of Humanity
  By Chris Skinner
- Computational Fairy Tales
  By Jeremy Kubica
- The Pattern on the Stone: The Simple Ideas That Make Computers Work
  By Daniel Hills
- Algorithmic Puzzles
  By Anany Levitin
- Superintelligence: Paths, Dangers, Strategies
  By Nick Bostrom
- Machines of Loving Grace: The Quest for the Common Ground Between Humans and Robots By John Markoff

MATHEMATICS

- The Great Mathematical Problems
  By Ian Stewart
- Fermat's Last Theorem
  By Simon Singh
- Beyond Infinity: An Expedition to the Outer Limits of Mathematics By Eugenia Cheng

Puzzle 5: word ladder

Here is one solution:

L I S P

L I M P

L A M P

L A M A

L A V A

J A V A

Puzzle 6: bit ladder

Here is one solution:

0 0 0

0 0 1

0 1 1

0 1 0

1 1 0

1 1 1

10. Extreme logical thinking: Eating at Quonk

That answer is 3: Babs and Yabu eat at Quonk
Why?
We know Alice and Zach eat together at Quonk. That means that EITHER

- the woman who likes to eat there is Alice OR
- the man who likes to eat there is Zach.

It is not BOTH Alice and Zach who like to eat there as then they would have eaten somewhere else.
This means that the woman and man in question is EITHER

- Alice and Yabu OR
- it is Babs and Zach.

We cannot tell which though. Luckily, that does not matter, we have enough information. In both cases we get the same conclusion.
If it is Alice and Yabu that like Quonk, then:

- Babs and Yabu would eat there because of Yabu.
- Alice and Yabu wouldn't because both are there.
- Babs and Zach wouldn't because neither Babs nor Zach eat there.

If it is Babs and Zach that like Quonk then:

- Babs and Yabu would eat there because of Babs.
- Alice and Yabu wouldn't because neither Babs or Zach are there.
- Babs and Zach wouldn't because both are there.

So whichever the pair is:

- Babs and Yabu would eat there.
- Alice and Yabu wouldn't eat there.
- Babs and Zach wouldn't eat there.

18. The Swap Puzzle

The following are efficient solutions for each board.

The level 1 puzzle can be solved in 3 moves as follows:

Step 1: **Square 1** GETS THE PIECE FROM **Square 0**

Step 2: **Square 0** GETS THE PIECE FROM **Square 2**

Step 3: **Square 2** GETS THE PIECE FROM **Square 1**

The level 2 puzzle can be solved in 8 moves as follows:

Step 1: **Square 2** GETS THE PIECE FROM **Square 1**

Step 2: **Square 1** GETS THE PIECE FROM **Square 3**

Step 3: **Square 3** GETS THE PIECE FROM **Square 4**

Step 4: **Square 4** GETS THE PIECE FROM **Square 2**

Step 5: **Square 2** GETS THE PIECE FROM **Square 0**

Step 6: **Square 0** GETS THE PIECE FROM **Square 1**

Step 7: **Square 1** GETS THE PIECE FROM **Square 3**

Step 8: **Square 3** GETS THE PIECE FROM **Square 2**

The level 3 puzzle can be solved in 15 moves as follows:

Step 1: **Square 3** GETS THE PIECE FROM **Square 2**

Step 2: **Square 2** GETS THE PIECE FROM **Square 4**

Step 3: **Square 4** GETS THE PIECE FROM **Square 5**

Step 4: **Square 5** GETS THE PIECE FROM **Square 3**

Step 5: **Square 3** GETS THE PIECE FROM **Square 1**

Step 6: **Square 1** GETS THE PIECE FROM **Square 0**

Step 7: **Square 0** GETS THE PIECE FROM **Square 2**

Step 8: **Square 2** GETS THE PIECE FROM **Square 4**

Step 9: **Square 4** GETS THE PIECE FROM **Square 6**

Step 10: **Square 6** GETS THE PIECE FROM **Square 5**

Step 11: **Square 5** GETS THE PIECE FROM **Square 3**

Step 12: **Square 3** GETS THE PIECE FROM **Square 1**

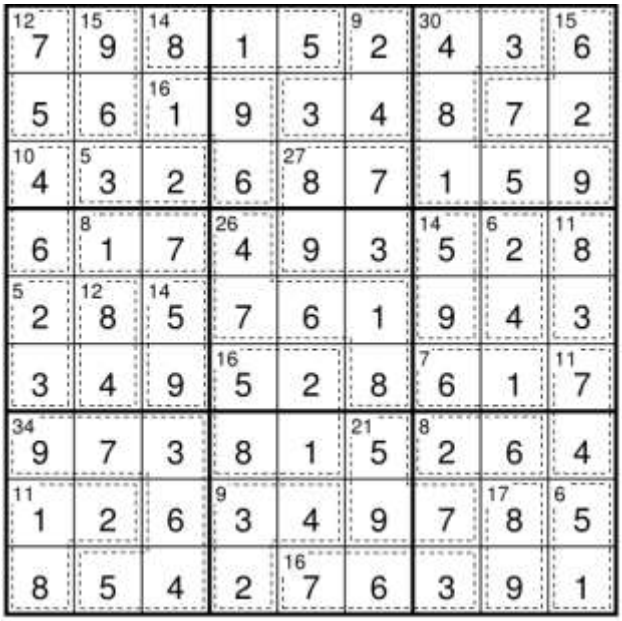
Step 13: **Square 1** GETS THE PIECE FROM **Square 2**

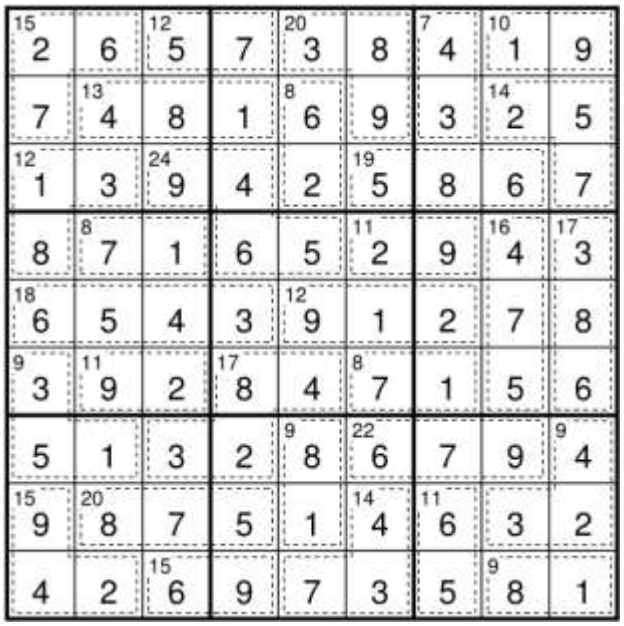
Step 14: **Square 2** GETS THE PIECE FROM **Square 4**

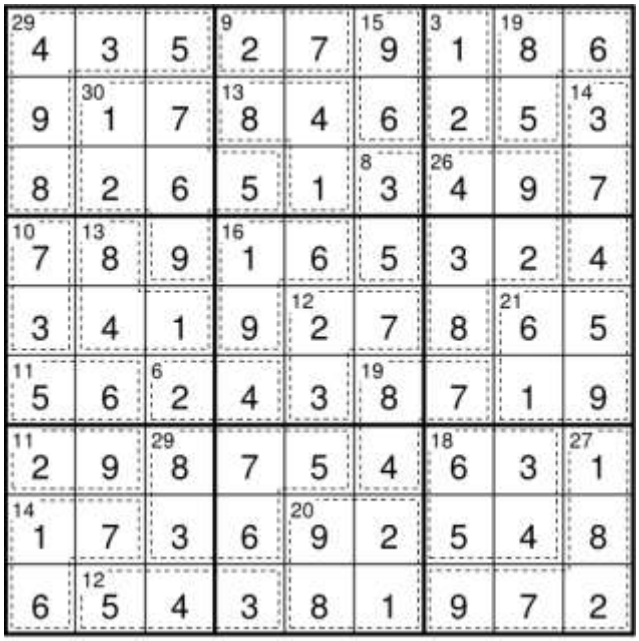
Step 15: **Square 4** GETS THE PIECE FROM **Square 3**

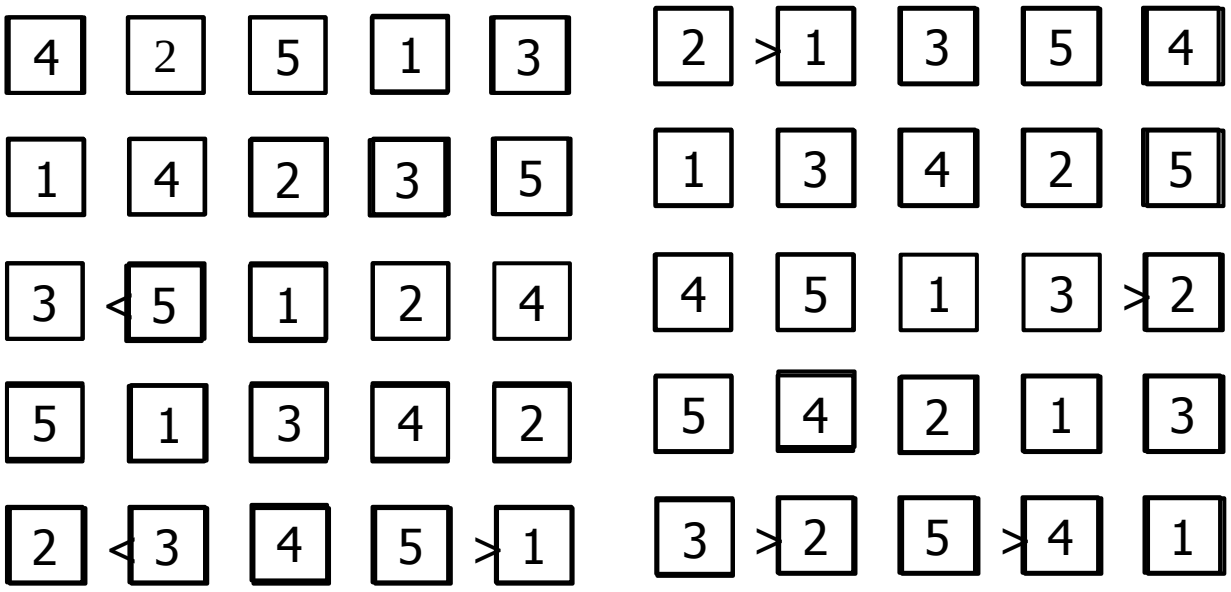
PUZZLE ANSWERS:

Mathematics








4 2 5 1 3
2 > 1 3 5 4
1 4 2 3 5
1 3 4 2 5
3 < 5 1 2 4
4 5 1 3 > 2
5 1 3 4 2
5 4 2 1 3
2 < 3 4 5 > 1
3 > 2 5 > 4 1

6	×	4	+	9
×		-		+
5	+	7	÷	3
-		+		×
1	+	8	+	2

= 33

= 4

= 11

= 29 = 5 = 24

7	×		×	9
+		+		-
8	-	2	-	1
-		+		÷
5	+	3	+	4

= 378

= 5

= 12

= 10 = 11 = 2

BEGINNER										ANSWER
15	x 2	-8	HALVE IT	x 4	+1	÷ 9	MULTIPLY IT BY ITSELF	-7	HALVE IT	9

INTERMEDIATE										ANSWER
89	+11	3/5 OF THIS	-5	2/11 OF THIS	MULTIPLY IT BY ITSELF	-19	÷ 9	x3	DOUBLE IT	54

ADVANCED										ANSWER
4	MULTIPLY IT BY ITSELF TWICE	+16	70% OF THIS	-2	7/9 OF THIS	-3	33⅓% OF THIS	x100	50% OF THIS	65

FRANCIS HOLLAND SCHOOL
SLOANE SQUARE

39 Graham Terrace
London SW1W 8JF

tel: 020 7730 2971
fax: 020 7823 4066

office@fhs-sw1.org.uk
www.fhs-sw1.org.uk