PULSE

Science magazine

15 P 92 U

53 I 34 Se

OCTOPUSES

How intelligent are they, and are they sentient?

TOOTHPASTE

How are colours kept separate in toothpaste?

MICROBIAL CONSCIOUSNESS

Are bacteria conscious?

Image credit: Aquarium du Québec, 2021

North London Collegiate School
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GASTRIC CANCER

While gastric cancer is not in the top ten most common cancers, it is second in terms of the number of deaths it causes (Smita et al 2021). Every year, there are approximately 990,000 people diagnosed with gastric cancer around the world, of whom around 738,000 die (Ferlay & Brey, 2010). The incidence presents very differently in different places with almost over 50% of gastric cancer occurring in developed countries. The probability of gastric cancer formation is higher in areas like Central and South America, Eastern Europe, and East Asia (China and Japan), whereas Australia and New Zealand, Southern Asia, North, and East Africa, and North America are among the low-risk areas (Ang & Fock, 2014). The percentage varies between 10% and 30% across Europe (Matsuda, & Saika, 2013).

Gastric cancer is a multifactorial disease, where many factors can influence its development including many non-modifiable variables, such as age, sex, and race/ethnicity, and also some factors that can be controlled, such as infection with *Helicobacter pylori* bacteria, smoking, and diets high in nitrates and nitrites (American Institute for Cancer, 2018). However, there are some special cases such as a history of mucosa-associated lymphoid tissue lymphoma, previous stomach surgery, and pernicious anemia (Smita et al 2021) which increase the likelihood of developing the disease. Having a first-degree family with gastric cancer is also a big risk factor as several inherited cancer syndromes are accredited with gastric cancer such as diffuse gastric cancer (CDH1) syndrome where 80% of patients will develop cancer. Although it is not really common, gastric cancer is still a significant unmet clinical problem. It is important to aim for earlier diagnosis utilizing the endoscopic examination approach, which enables the early detection and excision of cancer, in order to improve the five-year survival rate of people with this cancer.

AUTHOR: Manlin G11
SOURCES: lhttps://www.bilibili.com/video/BV1VT4y1f71t?spm_id_from=333.337.search-card.all.click
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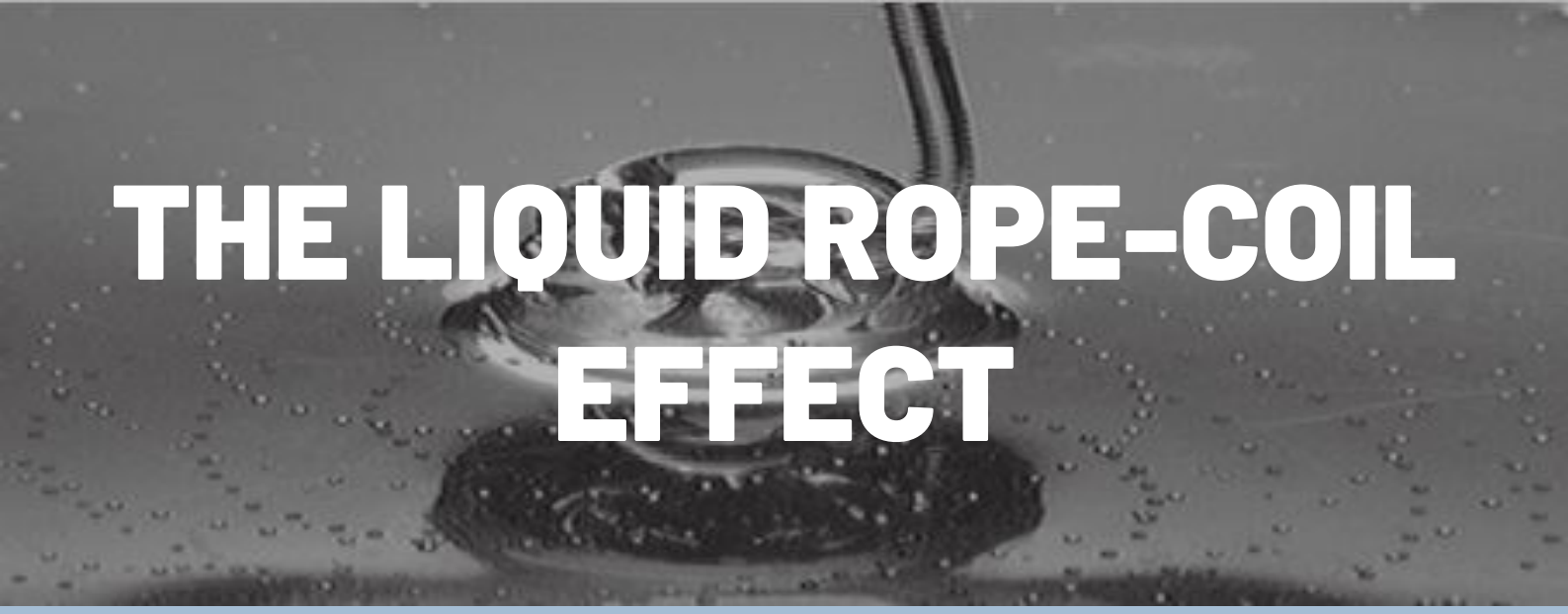


THE LIQUID ROPE-COIL EFFECT

Have you ever noticed what happens to honey when it falls? After falling from a high place, it will not immediately spread out as one might expect, but will circle and accumulate into a spiral structure. This phenomenon is called the Liquid Rope-Coil Effect.

In the late 1950s, Americans George Barnes and Richard Woodcock noticed this phenomenon: the tendency for a falling stream of very viscous liquid to coil like a rope when it strikes a horizontal surface resulting in the building of a "cone" of liquid of considerable height above the surface. This phenomenon is different from water flow. Water will flow out slowly and form a plane when falling from a height because it has low viscosity - the attraction between molecules is not large - so the process of spreading is very rapid. However, in viscous honey, the attraction between molecules is relatively large, which makes the liquid just touching the plane fall down before it can disperse. This phenomenon is not unique to honey, but can also be seen in the falling of some colloids - mixtures in which solid particles are dispersed throughout a fluid.

If the viscous liquid falls at a very low distance, the Liquid Rope-Coil Effect will not occur. However, as the falling distance continues to rise, the formed spiral part at the bottom will give a horizontal component to the vertical part and make it swing left and right. Because the center of the winding rope is not fixed, it rotates along a circular track. So the Liquid Rope-Coil Effect that we see appears slowly. When the falling distance is too high, the spiral part can no longer affect the trajectory of the vertical falling part, so the upper end of the fluid is almost straight, and the lower end is the stacking part. Therefore, the shape of the object landing, its viscosity, gravity and friction will affect the formation of the Liquid Rope-Coil Effect. When the circling motion is steady, it allows us to analyze it in a rotating frame which yields a balanced dynamical equation for numerical calculation. Experimentally, the dependence of circling frequency on parameters such as viscosity, fluid density, falling height characterizes the dynamical properties of the rope-coiling motion. Interestingly, there exists a rheological (flow of matter) transition in this motion and it can be seen directly as the configuration of coiling changes with falling height.

AUTHOR: Xilan G11
SOURCES:https://aapt.scitation.org/doi/pdf/10.1119/1.1996110#:~:text=The%20tendency%20for%20a%20falling,above%20the%20surface%20is%20observed.

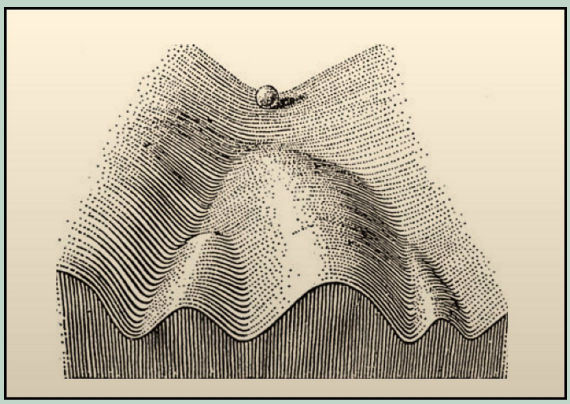
An everyday phenomenon, the tendency of viscous fluids to coil into a helix is still not fully understood by physicists

SCIENTISTS REVERSE BIOLOGICAL AGE OF MICE

For decades, popular theory postulated that ageing is caused by the accumulation of mutation in one's DNA over the course of one's life, resulting in cells losing their identities and causing the failure of tissue and organ. However, in recent years, scientists have noticed that many types of old cells have a paucity of mutations (De Majo et al., 2021; Kaya et al., 2015). Additionally, strains of mice or people that suffer from higher mutation rates show insubstantial evidence of premature ageing (Narayanan et al., 1997; Robinson et al., 2021), and mammals cloned from old somatic cells produce organisms with unaffected lifespans (Burgstaller and Brem, 2017).

The first evidence that the loss of epigenetic (relating to the expression of genes) information could be a potential cause of ageing emerged from yeast studies in the 1990s. Multiple studies showed that epigenetics changes are not merely a biomarker for ageing but a direct cause of it (Dang et al., 2009; Feser et al., 2010; Hu et al., 2014; Kaeberlein et al., 1999).

DNA is packaged into chromosomes in the nucleus for the majority of its lifespan. These chromosomes are made up of proteins and DNA that can loosen and tighten their structure to control their expression. This is essential for all differentiated cells; it would be disastrous if the cells in your eyes suddenly started producing hydrochloric acid. One can think of a cell as being situated someplace on an epigenetic landscape: a model of the developmental pathway that cells undergo.



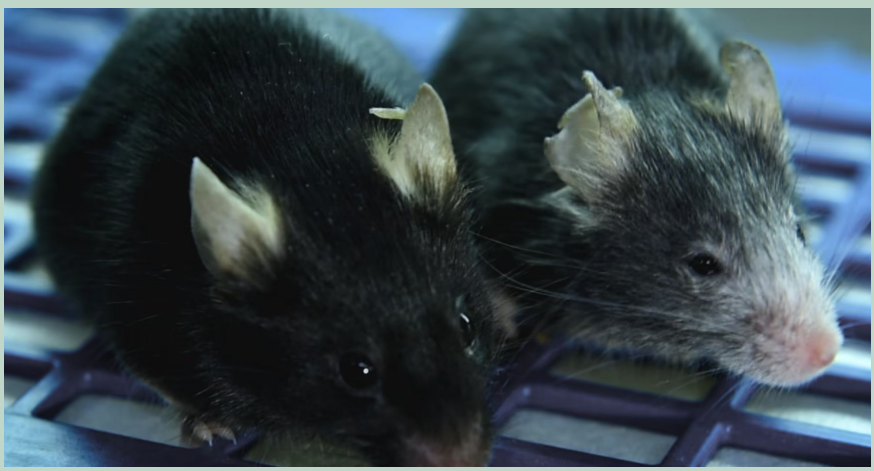
We can imagine a cell's journey to be akin to a ball rolling down a hill. At the top, we have a totipotent cell, one that has the potential to divide and reproduce to create a whole new functioning organism: a zygote, for example. Once the ball has rolled a little more down the hill, it becomes a pluripotent cell, one that has the potential to become almost all cell types but cannot evolve into its own organism (stem cells, essentially). From here the cell can go a number of ways, differentiating to achieve several different functions. Cell identity is specified by chromatin structures (the complex that chromosomes are made of) that direct the cells into the valleys of the Waddington landscape until terminal differentiation (Waddington, 1957). The catch is that the metaphorical ball can never roll back uphill after its terminal differentiation. This being said, all cells in an organism have the exact same set of DNA (save for mutations to it) so this begs the question of how permanent differentiation is even possible in the first place.

The answer lies in epigenetics. There are many different ways that gene expression is controlled in eukaryotic cells.

DNA methylation occurs at cytosine bases in DNA strands: they are converted to methylcytosine with DNA methyltransferase enzymes (DNMTs). These methylated cytosines are usually directly adjacent to a guanine nucleotide. This results in another methylcytosine diagonal to the first (due to complementary base pairing rules). This methylation decreases transcription rates in two primary ways: physically impedes the binding of proteins required to transcribe the DNA into mRNA and attracts proteins to the locus of methylation that repress transcription. Another way in which gene expression is controlled is through the structure of chromatins: the tightness of genes packaged up in a chromatin controls whether they are expressed or not. Proteins that transcribe DNA into mRNA cannot get to the genes if they are tightly wound up.

A recently published international study, thirteen years in the making, directly implicates the degradation of the epigenetic information of a cell as a cause of ageing rather than changes the cell's DNA itself and backs this up with empirical evidence. Researchers found that epigenetic changes, changes in DNA methylation patterns, are found in multicellular organisms to cause ageing (Sen et al., 2016). This being said, we actually still do not know exactly why mammalian epigenomes change over time, although we can draw some conclusions from yeast. A major driver to changes in the epigenome of yeast are double stranded DNA breaks (DSB)—DNA gets completely severed and needs to be repaired by epigenetic factors that usually deal with the regulation of the genome. The leading theory is that ageing in eukaryotes is due to the loss of epigenetic information over time, which is driven by a mechanism that initially evolved to regulate responses to damage such as a DSB (Yang et al., 2023). This repair causes chromatin reorganisation which results in the flattening of the epigenetic landscape: causes cell identity to be lost (essentially what ageing is).

This theory was tested *in vivo* through induced changes to the epigenome through causing DSBs without mutation (changes were not made to coding sections of genes) in mice. These mimic the cuts in DNA that mammalian cells experience regularly in response to interaction with the environment. After epigenetic factors coordinated repairs of the DSBs, they would return to their previous locations. However, as time went on these factors failed to return to the proper loci, instead drifting away from them. The epigenome became disorganised and the landscape began to flatten: chromatin was unspooled and condensed in the wrong places. When scientists tested how 'biologically' old the mice were, based on how many sites had lost methyl groups that should have been there, the treated mice had aged significantly more than the untreated mice in the same amount of time.

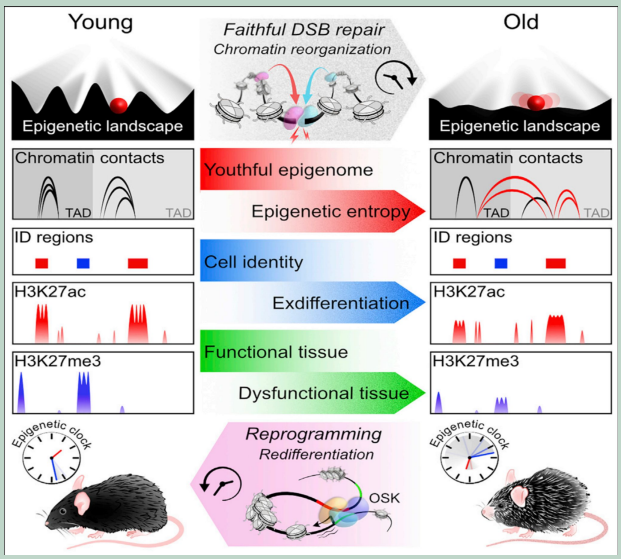


After this, researchers delivered three genes that are active in stem cells, named OSK, to the mice. These genes can help to rewind a mature cell back to an earlier state. The treated mice's organs and tissue resumed a more youthful state and its epigenetic information was restored.

The exact process through which this works still remains unclear to researchers however they think that mammalian cells maintain a 'backup copy' of their epigenome that can then be reinstated to restore the cell back to a youthful state.

Regardless, these experiments consolidated the fact that the manipulation of the epigenome can drive ageing back and forth at accelerated rates. Researchers are now looking for methods beyond OSK gene therapy to restore lost epigenetic information and investigating other ways that they could manipulate the epigenome to produce desirable results. True medical applications, however, are a long way off and still require extensive testing on larger mammalians such as primates and humans themselves. In the words of Dr. Sinclair, "We're talking about taking someone who's old or sick and making their whole body or a specific organ young again, so the disease goes away," he said. "It is a big idea. It is not how we typically do medicine.".

This research really opens up a new door for scientists attempting to rejuvenate tissue and cells: a method to potentially delay, prevent or entirely eliminate age-related diseases such as type 2 diabetes, neurodegeneration, and frailty.



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AUTHOR: Rohan Janaki

DNA CLONING

Have you ever wondered how the Kaminoans managed to manufacture millions of clone troopers in Star Wars or how Dolly the sheep came to life? This happened due to the wonders of cloning. There are three main types of cloning: reproductive cloning (creating copies of whole animals), therapeutic cloning (creating embryonic stem cells) and gene cloning (creating copies of genes). DNA cloning falls under the umbrella of gene cloning and is the process of replicating and making a large number of identical copies of a segment of DNA. The DNA molecules thus produced can be used to help understand the effect of a mutation of a gene, in gene therapies and in the manufacture of proteins.

In a typical DNA cloning procedure, the DNA fragment of interest is placed into a circular piece of DNA known as plasmid with the help of enzymes. Now it has fabricated a molecule of recombinant DNA which is made of fragments of various sources. Next the recombinant plasmid is added in bacteria which will soon grow up and reproduce. This happens via a process known as transformation. During reproduction the bacteria will duplicate the recombinant plasmid and it will be passed on to its progeny. You might be thinking why do biologists use DNA sequences in plasmids. This is because we need DNA to conduct scientific investigations and create plasmids. Another use of it could be to code a protein and use the bacteria to spread it around.

Below the steps for DNA cloning will be provided. This is the method scientists use in the lab to perform procedures.

The first step of DNA cloning is to cut and paste the DNA gene into the plasmid. The enzymes required for this step are the restriction enzyme and the DNA ligase. The restriction enzyme will cut the DNA gene in a specific place or target. The gene is then inserted into the plasmid and is bonded with the help of the DNA ligase. The plasmid is now known as recombinant plasmid. The second step of this procedure is the recombinant plasmid being placed in a bacteria. The bacteria is forced to be in an area which has high temperature. This is known as transformation. The plasmid has an antibiotic resistance gene to survive the presence of antibiotics. When the plasmid having the bacteria are settled on a nutrient consisting of antibiotics, the bacteria containing the plasmid survive while the other ones die. The bacteria containing plasmid is then cultured. The bacteria is given a chemical sign that helps to target the protein. Once protein production is completed, the bacteria is split to release the protein. The protein is purified and is isolated from the other parts of the bacteria.

To conclude this article, cloning is a gateway to the future opening many ideas that scientists can experiment and investigate. I believe this could be even more widespread and improved due to the advancement of technology.

AUTHOR: Zaid G6

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RHEOLOGY WITH TOOTHPASTE

Toothpaste is something that all of us use everyday. Some toothpastes are multicoloured with white, blue, green red or pink stripes. But had you noticed when you are squeezing it out of the tube onto your toothbrush that the stripes remain intact with the colours never mixing together? This phenomenon links to the concepts of Bingham fluids and rheology - the study of the flow of matter, primarily in a fluid state, but also as "soft solids" like pastes.

A fluid is anything that flows, unlike solids which maintain their shape. Fluids can be divided into Newtonian and non-Newtonian fluids. Newtonian fluids obey Newton's law of viscosity, with the viscosity being independent of the shear rate (the rate at which fluid layers move past each other). Non-Newtonian fluids do not follow Newton's law and, thus, their viscosity is not constant and is dependent on the shear rate. Non-Newtonian fluids can be further divided into several different types including Bingham fluids, which are materials that behave as a rigid body at low stresses but flow as a viscous fluid at high stress. In the case of toothpaste, the stress that turns it fluid is caused by the action of us squeezing it and results in the coloured paste layers sliding relative to each other and not mixing together.

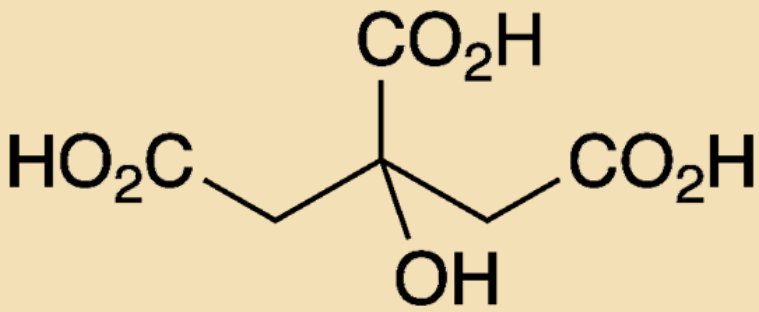
So that it is clear that toothpaste is a Bingham Fluid so that it keeps the shape of the colour stripe when you squeeze it. Also important to consider is the Reynolds number, which is a quantity to decide the flow of a fluid through a pipe. The Reynolds number indicates how flow speed can determine the properties of a fluid. When the speed is faster, then the fluid will be more messy. For toothpastes, the Reynolds number is very small, so it is laminar flow. Therefore colour stripes of toothpaste do not mix.

AUTHOR: Manlin G11

SOURCES: https://www.lamyrheology.com/EN/toothpaste/
https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.rheologylab.com%2Farticles%2Fcosmetic-personal-care%2Ftoothpaste-rheology%2F&psig=AOvVaw0ihqX-bN-o-j7Wt_J2VE2y&ust=1678175343258000&source=images&cd=vfe&ved=0CA4QjhxqFwoTCPiO87zoxv0CFQAAAAAdAAAAABAI

Rheology explains why toothpaste keeps its stripes when it comes out of the tube

MOLECULE OF THE MONTH



Can you guess the molecule of the month?

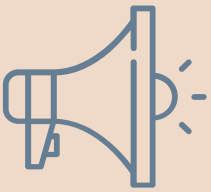
Work through the clues to solve the mystery. If you solve with the help of just the first clue - well done, your chemical knowledge is on par with members of the american chemistry society. If you need a few more clues, don't worry, we won't judge! And if you are left in the dark after reading all the clues, scan the QR code to find out the answer and learn more about the molecule.

CLUE 1: My name may makes people think of fruit juice

CLUE 2: I was isolated from lemon juice by Swedish–German chemist Carl Wilhelm Scheele in 1784

CLUE 3: My chemical formula is $C_6H_8O_7$

AUTHOR: Manlin G11



DID YOU KNOW?

If you took out all the empty space in our atoms, the human race could fit in the volume of a sugar cube!

Did you know that Bananas are radioactive? Bananas contain an element known as potassium which decays over time resulting in the banana being a bit radioactive.

Did you know that humans aren't the smartest animals in the world? Its Chimpanzees!

Did you know that humans inherited genes from other species of animals?

SCIENCE RIDDLES

1. "I was once an old massive star and soon I will be a brightly colored gas cloud, but for now I am a massive explosion. What am I called?"

2. "I am a hypothetical tunnel, a short-cut if you will, of space-time which connects far away regions. I am what?"

3. "What periodic element do pyromaniacs love the most?"

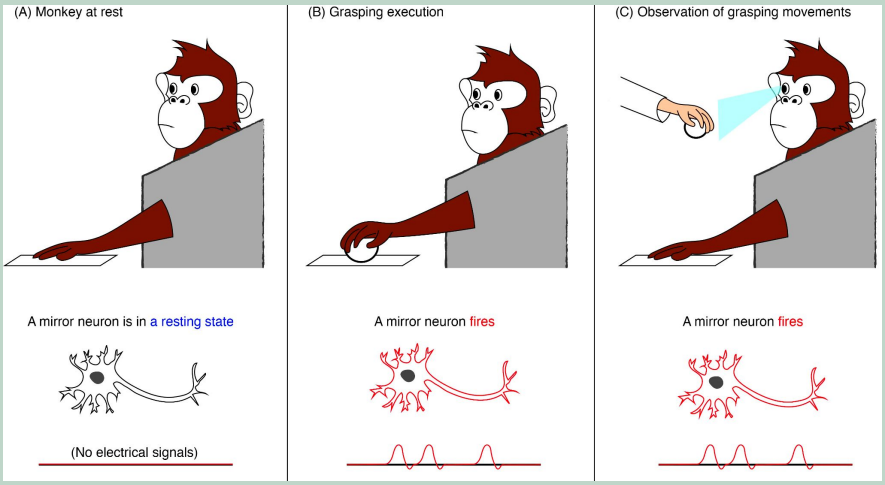
4. "What 2 periodic elements can heal when put together?"

AUTHORS: Jasper and Zaid G6

Answers: 1: Supernova, 2: Wormhole, 3: Arsenic, 4: Helium and Aluminium

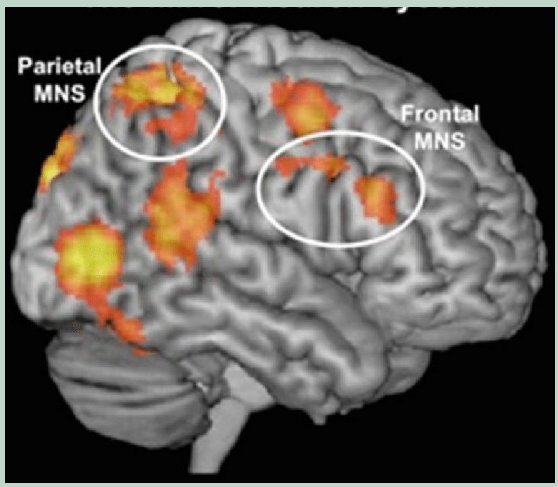
WHY DO WE KEEP COPYING OTHERS, WITHOUT EVEN NOTICING?

Maybe you've noticed that you and your friends all behave similarly. For instance, your friend begins using the word "absolutely" in nearly every sentence, and you follow unconsciously. Perhaps you adjust your accent, pace and volume to sound more like the person you are speaking to. Also, perhaps you yawn after seeing someone else do so. These "contagious" events are not accidental; rather, they are the basic examples of effective empathy, attributed by "mirror neurons".



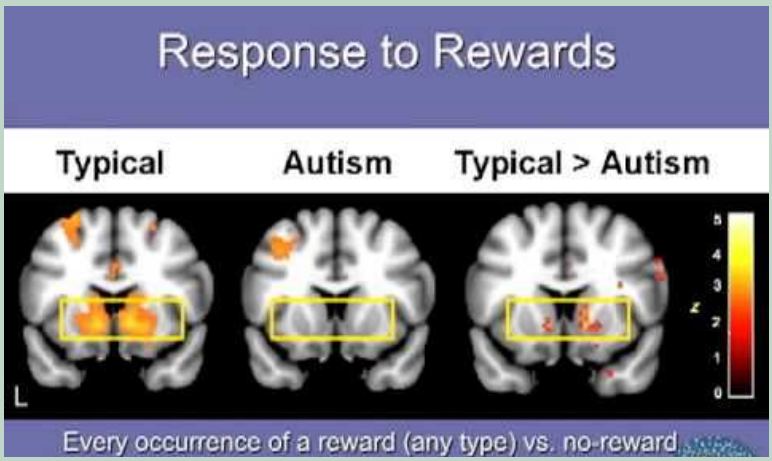
Mirror neurons are a specific type of brain cell that respond when we perform an activity and react in the same way when we witness another person carry out the same action. Mirror neurons were first discovered in macaque monkeys. When a monkey observed the researchers grasping a peanut, the monkey's motor neuron started to fire. The neurons fired are in an area of their premotor cortex called F5, which only responds to certain actions — it responds to sound and encodes the intention linked to the observed action. It means that mirror neurons are associated with imitation, the basic mechanism of learning.

In humans, mirror neurons are located in the posterior inferior frontal gyrus, adjacent to the ventral premotor cortex, and the rostral part of the inferior parietal lobule. As imitation involves social interactions and promotes cognitive development, mirror neurons are extremely important in education, so unconscious mimicry is a part of human nature.



Without any explicit training, children can learn how to tie shoelaces by watching their parents do it. Children are also able to learn language, musical instruments, and other skills via observation attributed to mirror neurons. Additionally, mirror neurons promote empathy. By "mirroring" what others are experiencing, such as smiling back when we see a baby giggling or feeling sad when we see someone sobbing in a movie, the mirror neuron system and limbic system interact to help us understand others' emotions instinctively on a cognitive level. As human beings are social animals, we desire the acceptance of our friends and admire power in others. Therefore, the empathy inspired unconscious mimicry, with the support of the mirror neuron system (MNS).

Mirror neurons also offer explanations for autism spectrum disorder (ASD). ASD is a developmental disorder that disrupts the process of social learning experience, including imitation, communication and affect sharing. According to fMRI research, children with ASD exhibit reduced MNS activity during social mirroring — the higher the impairment, the lower the activity. Because the mirror mechanism is disturbed, individuals with ASD are unable to share their felt experiences with others, or feel the same feelings and sensations while seeing others' experiences. By understanding MNS, treatments like Early Start Denver Model are developed to encourage social and cognitive skills of altruistic children.



In conclusion, mirror neuron activity promotes unconscious imitation, a key method of social and cognitive development, especially in children. They are also linked to empathy, which fosters social interactions and emotional comprehension. The notion of mirror neurons also has implications for the evolution of language and can be used to explain a range of neurological disorders, including ASD.

Therefore, it is very normal if your behaviour changes to match the same of your friends, family, or role models — it is part of being human. Don't worry, copying others' traits won't make you lose your uniqueness.

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Signs and symptoms of autism spectrum disorders (2022) *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention. Available at: https://www.cdc.gov/ncbddd/autism/signs.html#:~:text=Autism%20spectrum%20disorder%20(ASD)%20is,or%20repetitive%20behaviors%20or%20interests.

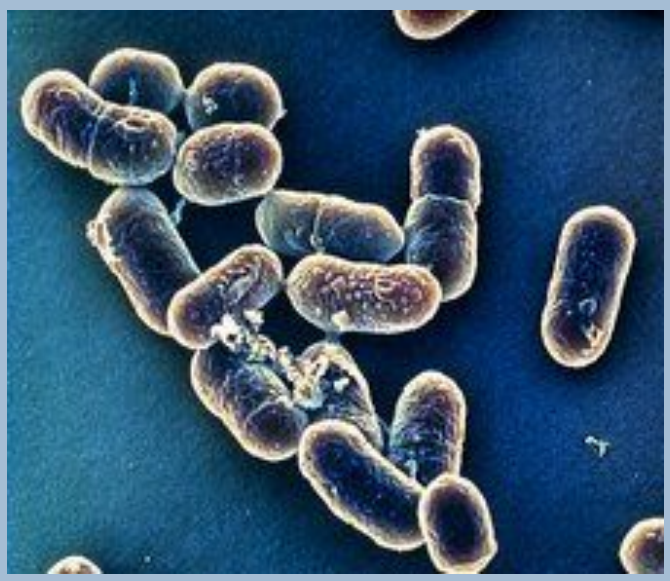
AUTHOR: Wendy Liu

MICROBIAL CONSCIOUSNESS

Consciousness, as a quality neither directly observable nor even able to be empirically proved, divides the scientific community with two overarching questions: which organisms apart from humans are conscious, (if any), and when did consciousness originate?

Currently, many hypotheses exist regarding the origins of consciousness with differing degrees of scientific probability, stating a range of junctures when consciousness could have emerged. One hypothesis proposes that consciousness began with multicellular plants 850 million years ago; another suggests animals such as jellyfish were the first conscious organisms when they developed thousands of neurons 580 million years ago; Panpsychism is the theory that consciousness began when the universe formed around 13.7 billion years ago, while the most scientifically supported hypothesis is that consciousness began when animals such as birds and mammals developed much larger brains with hundreds of millions of neurons, around 200 million years ago.

However, there has been a recent movement supporting the theory that bacteria and other single-celled microorganisms possess high levels of intelligence, or even consciousness. Although past efforts have been dedicated to studying intelligent processes in humans, other mammals, and birds, the topic of microbial intelligence has recently been gaining traction. Analysis of microbial models and comparative genomics studies confirm that microbes have evolved diverse means of memory, learning, and processing information; all of which are classified as 'intelligent behaviour'. The most studied manifestations of intelligence in the microbial world include decision-making, problem-solving, associative learning, and quorum sensing.



Microbes are able to monitor their environment, process information, and intelligently make a decision. These decisions can be made through various mechanisms and networks such as gene-expression regulation, signalling pathways, transport, metabolism, etc. There are ongoing studies involved in constructing genome-wide protein interaction networks to gain a better understanding of the molecules and interconnections required for microbes to make decisions. The most well-studied example of microbes decision-making capabilities is the chemotaxis of E. coli. These microbes decide by monitoring their environment through plasma membrane receptors. If these receptors bind to certain ligands, a signalling pathway involving phosphorylation and methylation is induced within the cells. In this example, it is the level of phosphorylated CheY, a downstream protein of the signalling pathway, that ultimately decides which of two movements the E. coli cells undertake.

When the amoeba Dictyostelium searches the surface of a Petri dish for food, it makes frequent turns. But it does not do so entirely randomly. If it has just turned right, it is twice as likely to turn left as right on its next turn, and vice versa. In some way, it "remembers" which direction it last turned. Human sperm also have the same ability. E. coli goes one better. This bacterium spends part of its life cycle travelling through the human digestive system encountering different environments as it goes. In the course of its journey, it encounters the sugar lactose before it finds the related sugar, maltose. At its first taste of lactose, it switches on the biochemical machinery to digest it – but it also partially activates the machinery for maltose, so that it will be ready to digest maltose as soon as it reaches the lactose. To show that this was not simply hard-wired, the researchers from Tel Aviv University grew E. coli for several months with lactose, but without maltose. They found that the bacteria gradually changed their behaviour, so that they no longer bothered to switch on the maltose-digesting system. Remarkable though these behaviours are, we have only scratched the surface of what single-celled organisms can do. With so many microorganisms still unknown, and their behaviour undiscovered, the question of the emergence of consciousness is one that will remain extremely relevant, yet unsolved, in years to come.

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HOW SMART ARE OCTOPUSES?

The topic of intelligence in non-human animals has always been a fascinating field for researchers, scientists and wildlife enthusiasts. And though intelligence in great apes like chimpanzees and marine mammals like dolphins have been somewhat well documented, the animal whose unbelievable intelligence remains largely unstudied is the octopus.

Octopuses are invertebrates. They are often described as having a soft body, eight arms to manipulate the environment, and a sharp beak to chop and slice up prey. Octopuses also have three separate hearts: a systemic or main heart that circulates blood around the body and two branchial or gill hearts that pump it through each of the two gills. In respiration, the octopuses mainly use their syphons, which also have muscles that control water flow to aid the animal in propulsion. Ink sacs located under the digestive glands produce dark, mucus-lined ink that confuses potential predators and gives the animal a chance to escape in emergencies. These fascinating creatures also coordinate thousands of colour-changing cells under their skin called chromatophores that can change their colour and texture in seconds, giving them some of the best camouflage skills in the animal kingdom.

However, the most dazzling feature in the octopus's body is undoubtedly the brain. The octopus has 8 so-called "mini brains" located on each of its eight limbs in addition to the central brain located between its two eyes. This allows the octopus to perform complex actions like capturing prey or escaping from predators more efficiently. Its brain-to-body mass ratio is the largest compared to other invertebrates and its nervous system most complex among all invertebrates. The complexity of their neural system combined with their large size and dissimilarity with humans make them a widely used animal in neurophysiological experiments. Octopuses are shown to be able to use tools. Tool use is seen in the zoological community as a hallmark of cognitive ability, and is often associated with a high level of learning ability in animals. Excluding a few species of ants, octopuses are the only invertebrates to be observed that use tools in a natural environment. Many octopuses have been observed using two halves of a discarded coconut as protective shielding when stopping in exposed areas or when resting in sediment and moving around on the ocean floor. Blanket octopuses have been observed to rip off poisonous tentacles of the Portuguese man o' War, a species of jellyfish-like Hydrozoan, and use them as weapons for self-defence and aid in hunting.

According to Jon Ablett, curator of the NHM's cephalopod collection, octopuses have been known to build dens made out of stone and coral with a sealed protective entrance. Although most octopuses aren't social animals and they only come together to mate, an "octopus-city" called "Octolantis' ' has been found near the Australian east coast. This "city" has around 15 inhabitants, often observed fighting and communicating with each other. Octopuses have even been observed to 'get out of its tank, open the other tank, eat the fish, close the lid, go back to its own tank and hide the evidence.'

Researchers in the Seattle aquarium designed an experiment to test the recognition abilities of Giant Pacific octopuses. One researcher will feed the octopus regularly while another will often poke the octopus with a stick. After a few weeks, the octopus showed more interest in the "nice" researcher while trying to hide every time it saw the "mean" one, despite the fact that both people wore the same uniforms. This also demonstrates that octopus can recognize different faces and characteristics, even that of different species.

Another behaviour of the octopus that exhibits intelligence is the fact that they play. Playing helps animals gain experience with each other, improve their physical ability, and develop social bonds. Intelligent animals have more memory and ability to gain experience since they have more developed communication and physique. Octopuses have been observed to repeatedly blow jets of water at a pill bottle, causing it to go over a water jet in the tank and come back to the octopus. This does not benefit the octopus in any way, but rather is done to figure out the world around them and is an act of recreation. In 2008, a German aquarium's electrical system kept short-circuiting overnight. It turned out that an octopus named Otto climbed up the side of his tank and squirted water at the spotlights because he was bored and worked out he could turn them off. Octopuses have also been observed in many cases to steal scuba divers' cameras or gopro out of pure curiosity.

Octopuses are also conscious beings, as they can feel emotions. Octopuses are actually much more intelligent than us humans. If we could make an octopus do an IQ test, then we can find out that octopuses would outscore most humans on the maths portion at a genius level of above 140. Therefore they can feel emotions such as pain and try to avoid it.

The experience of pain is far more than a simple reflex to harmful injury; it's a complex emotional state, leading to distress or suffering. Octopuses have shown that they avoid places where they previously experienced negative emotions, even if they are free of pain at that very moment. In an experiment by Crook, after a single training session in a three-chambered box, octopuses that received an injection of acid into one arm showed clear avoidance of the chamber in which they received that shot. Octopuses are the most neurologically complex invertebrates on Earth, and yet surprisingly few experiments have focused on their potential to feel emotions like pain. Research found out that octopuses score most highly out of the creatures studied – more so even than their cousin the cuttlefish. They cannot only feel pain but also feel pleasure, bored or interested, companionship, anger/aggression, and many more.

Peter Ulric Tse, a neuroscientist at Dartmouth College who studies octopus cognition, tells the Times via email that octopuses "can express what we would call aggression when they feel threatened or when they feel their territory is under threat."A study published in iScience in March provides the strongest evidence yet that octopuses feel pain like mammals do, bolstering the case for establishing welfare regulations for these animals. Lynne Sneddon, a fish pain researcher at the University of Gothenburg in Sweden, says " The study shows beyond a doubt that [octopuses] are capable of experiencing pain."

In the study, the octopus was led into two rooms, one that it likes and one that it doesn't like. In the room it likes, it was being shot of acetic acid. After he was led to the room he doesn't like, he decided to stay in the room he doesn't like rather than going back to the room he likes which he felt pain. There is a lot of conscious progress that is happening when he decides through his mind about the pain and the rooms.

Peter Ulric Tse, a neuroscientist at Dartmouth College who studies octopus cognition, tells the Times via email that octopuses "can express what we would call aggression when they feel threatened or when they feel their territory is under threat."

But what's the reason behind the incredible intelligence and apparent consciousness of these clever creatures? The subject of cephalopod intelligence has long been a mystery due to the subject's difficulty in research and is seen as a paradox due to the immense dissimilarity between iconic intelligent animals, like mammals, and the cephalopods. Unlike other intelligent animals, like whales, humans, and parrots, cephalopods have an extremely short lifespan, meaning they have much less time to build up experience. According to a research done by scientists at BMC Biology, octopuses might have convergently evolved a gene that allows a higher level of intelligence. Scientists found that certain octopuses like the common octopus, the gloomy octopus, and the blanket octopus, have genomes filled with transposons, or jumping genes, a type of gene that makes up 45 % of the human genome. Jumping genes can copy and paste or cut and paste themselves to another location in the genome. Although most transposons are dormant in the human genome, scientists believe that one functional family of transposons dubbed LINE is crucial for learning and memory formation in the human brain. Recently, researchers also discovered the presence of LINE genes in the vertical lobe of octopuses, an area in the cephalopod brain mainly concerned with learning. This implies that octopods may convergently evolved crucial genes normally associated with higher intelligence in mammals, and researchers speculate that this may be the true reason behind the octopus' high intelligence and cognitive ability.

In conclusion, it has been empirically and scientifically proven that octopuses are capable of high levels of cognitive ability, including high intelligence and ability to feel emotions. There exists many examples and anecdotes that demonstrate the fact and much research has been done around the subject. According to livescience.com, on the nineteenth of November, the UK government proposed a new law wherein octopuses will be recognized as sentient beings. Recent scientific progress has revealed more about this amazing subject and it's evident that more research will only reveal more about this fascinating field.

AUTHOR: Mike & Loka G6

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THIS DAY IN SCIENCE

March 8 - 1618
Johannes Kepler discovers the third law of planetary motion, describing the orbits of planets around the Sun. The laws modified the heliocentric theory of Nicolaus Copernicus, replacing its circular orbits and epicycles with elliptical trajectories, and explaining how planetary velocities vary.

March 8 - 1934
A photograph by astronomer Edwin Hubble shows there are as many galaxies in the universe as there are stars in the Milky Way

March 13 - 1781
William Herschel discovers the planet Uranus

March 17 - 1845
The rubber band is patented by Stephen Perry in England

March 19 - 1915
Pluto is photographed for the first time but is not recognized as a planet

March 20 - 1916
Albert Einstein publishes his general theory of relativity

March 26 - 1953
Jonas Salk announces his polio vaccine

March 30 - 1842
Anesthesia is used for the first time in an operation by Dr. Crawford Long

AUTHOR: Danica G10

On March 8, 1934, a photograph by Edwin Hubble showed that there are as many galaxies in the universe as stars in the Milky Way

FEATURED SCIENTIST

Carolyn Ruth Bertozzi is an American chemist and Nobel laureate. She was born on October 10, 1966. Professor Carolyn Bertozzi's research interests span the disciplines of chemistry and biology, with a focus on cell surface sugar health and human enzymes.

Carolyn Bertozzi was awarded the Nobel Prize in Chemistry for her development of bioorthogonal reactions that allow researchers to chemically modify molecules within living systems and enable scientists to explore cells without disrupting their normal chemistry and track biological processes, focusing on cell surface sugars that are critical to human health and disease. Her research group analyzes changes in cell surface glycation associated with cancer, inflammation, and bacterial infection and uses this information to develop new diagnostics and treatments. One of Bertozzi's research interests is glycosylation, the normal cellular process by which sugars are added to proteins or other molecules. Scientists have known for decades that changes in glycosylation are associated with cancer, inflammation, bacterial infections, and other illnesses. Bertozzi reasoned that if she could develop a way to monitor glycosylation and measure it quickly, simply, and noninvasively, the results would deepen researchers' understanding of how cell surface sugars contribute to both health and illness and could open avenues for diagnosing and treating disease.

Toward this goal, she and her colleagues developed a chemical reaction that adds a marker molecule to cell surface sugars, but because glycans are critical participants in cell–cell adhesion and help mediate the mammalian immune system, the biopolymers are not directly genetically encoded and are therefore difficult to label using typical biochemical methods such as lectin and antibody labeling. So a new technique was refined for use in living animals. Their innovative approach, which Bertozzi dubbed "bioorthogonal chemistry," uses reagents that react with one another but not with naturally occurring cell surface molecules. Thus, the reagents do not interfere with the sugars' ability to carry out their normal signaling functions. Bertozzi's team has used the reaction to attach tracers to sugar molecules on cell surfaces in mice. The sugars they targeted are produced in elevated amounts by cancer cells and by inflamed cells.

The team's work suggests that this technique could potentially be used to attach tracers to diseased cells in patients, allowing doctors to pinpoint the location of the cells in the body and perhaps even target therapy. The techniques developed by Bertozzi are also being used in the biopharmaceutical industry to generate engineered protein drugs, including antibody-drug conjugates. She applies her nearly decades of experience as a chemist to medicine. In her own research, she has helped develop new, less expensive tests for tuberculosis, more effective tests for HIV, and new drugs that clear disease-causing proteins from the surface of cells. Benefit more people in medicine.

AUTHOR: Huaiyue & Yuhan G10


Carolyn Bertozzi
Laureate 2020

Taking science at University: Interview

Siobhan Killingbeck is a Geophysicist living in Canada. She took a geophysics university course in Scotland and has worked in many countries around the world. Below is an interview on what it is like taking geophysics at university, what jobs you can get with the degree and more.

Q. Which university did you study Geophysics at?
I studied Geophysics at the University of Edinburgh.

Q. To take Geophysics at the university of Edinburgh what exam results did you require to get accepted?
I took the Scottish Highers, which give no particular advantage when getting into the university of Edinburgh, and I was required to achieve three A's in math, physics and geography. (Using the IB curriculum you will need to achieve 32 overall points, including Mathematical analysis and approaches HL with a minimum score of 6, Physics with a minimum score of 5 and English with a minimum score of 5. Geography is recommended but is not necessary to meet the entry requirements.)

Q. What is your profession now?
I am a researcher for the university of Alberta, Canada. I specialize in glaciology (the study of glaciers and snow) and general geophysics. I work very closely with NASA and I do many field trips around the world.

Q. What professions could you have gone into with this degree?
Geophysics is an extremely broad course, and you can go into many different industries with the degree. Some of the most common industries people go into post graduation are oil and gas, meteorology (study of weather), natural disaster monitoring, astro-physics, a variety of jobs at NASA, Marine science and any other career direction.

Q. What are the pros and cons of studying geophysics in your opinion?
The best thing about the course in my opinion is the variety of post graduate options available. Another great thing about the course is the experiences at university. The variety of field trips to many different regions is amazing. One downside to taking geophysics in my opinion is that it requires a lot of math on a regular basis. If you don't like math, specifically equations, this course isn't a good option.

Q. What co curricular activities and work experience was required to take this degree?
Work experience isn't required to be accepted into the course, but it definitely is an advantage when getting accepted. I didn't have any work experience prior to university, but my co-curricular activities were an advantage for me. I was in multiple sports teams and did triathlons. Whilst at university, I got a lot of work experience through field trips to locations such as Norway and Hawaii where I got to study glaciers and volcanic activity.

University of Edinburgh housing/dorm option.

Edinburgh's earth sciences block.

MY FAVOURITE SCIENTIST - Dr Hill

Jonas Salk was born in New York City in 1914 to Russian-Jewish immigrants. He obtained a medical degree from New York University School of Medicine in 1939 and became a scientist physician at Mount Sinai Hospital. In 1942, he went to the University of Michigan on a research fellowship to develop an influenza vaccine and became assistant professor of epidemiology. In 1947, Salk was appointed director of the Virus Research Laboratory at the University of Pittsburgh School of Medicine. He would then develop the techniques that would lead to a vaccine to wipe out paralytic poliomyelitis. Polio is an illness caused by a virus that mainly affects nerves in the spinal cord or brain stem. The most severe form of polio can lead to someone not being able to move their limbs, called paralysis.

Contrary to the scientific opinion at the time, Salk believed that his vaccine, composed of an inactivated polio virus, could immunise the patient without infecting them. When given to volunteers, who had never had polio, they developed antibodies. He even gave the vaccine to himself, his wife and his children.

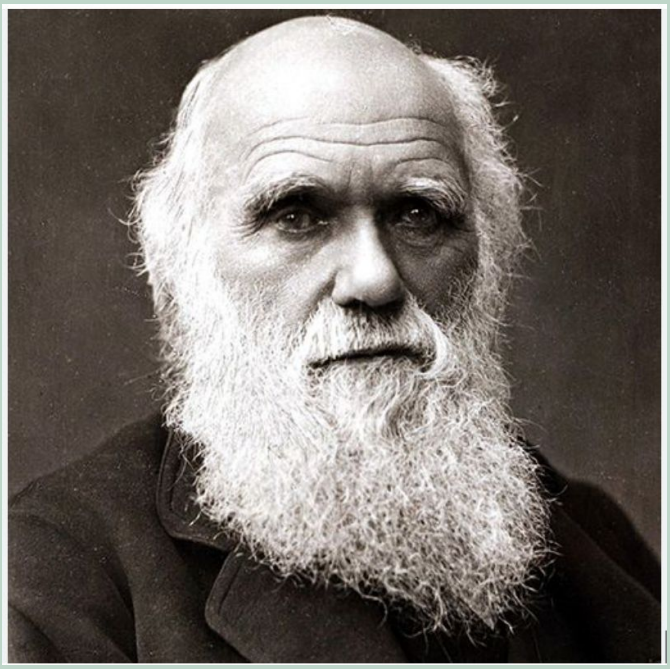
In 1954, the US began testing his vaccine on one million children, called the Polio Pioneers. The results proved that the vaccine was safe and effective. Polio in the US dropped from an average of 45,000 to 910 cases.

Salk had the opportunity to patent the polio vaccine and could have made a lot of money. Instead he gave away the vaccine for free. When asked who owns the patent on the vaccine he said:

"Well, the people, I would say. There is no patent. Could you patent the sun?"

In his final years, he searched for a vaccine against AIDS. His life's philosophy is memorialised at the Institute with his famous quote: "Hope lies in dreams, in imagination and in the courage of those who dare to make dreams into reality."

Jonas Salk (1914–1995) developed one of the first successful polio vaccines



"To kill an error is as good a service as, and sometimes even better than, the establishing of a new truth or fact."

- Charles Darwin

PULSE

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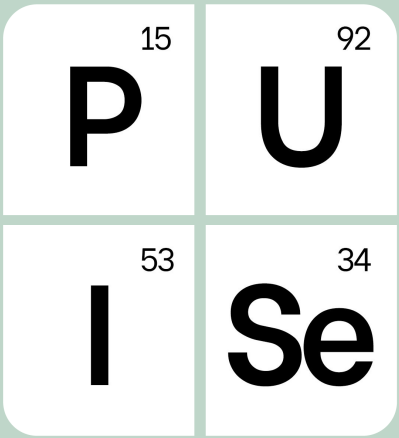

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Pulse CCA meets every Monday 3:45-4:45 in E620. We welcome guest articles from all members of our community. If you would like to learn more or submit an article please email adangerfield@nlcssingapore.sg

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