St Benedict's SCIENCE NEWS *Monthly*

Welcome to the November 2021 issue

SCIENCE NEWS *Monthly* is produced by the Science Department, St Benedict's Catholic Secondary School, Bury St Edmunds, Suffolk, UK.

SPECIAL EDITION: NOBEL PRIZES 2021

Alfred Nobel, the Swedish chemist after whom the prizes are named, was born on 21st October 1833. By tradition the Nobel Prizes are awarded in the month of Nobel's birth. This year's Nobel science laureates were announced during the first week of October. This November's issue includes some detailed information regarding the laureates' work for which they were awarded Science's most prestigious prize.

4th October: PHYSIOLOGY or MEDICINE

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https://www.bbc.co.uk/news/health-58787438
https://www.nobelprize.org/prizes/medicine/2021/press-release/

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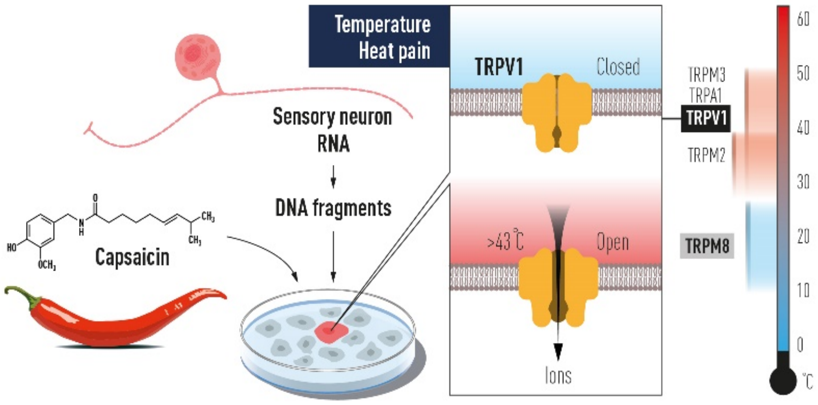
One of the great mysteries facing humanity is the question of how we sense our environment. The mechanisms underlying our senses have triggered our curiosity for thousands of years, for example, how light is detected by the eyes, how sound waves affect our inner ears, and how different chemical compounds interact with receptors in our nose and mouth generating smell and taste. We also have other ways to perceive the world around us. Imagine walking barefoot across a lawn on a hot summer's day. You can feel the heat of the sun, the caress of the wind, and the individual blades of grass underneath your feet. These impressions of temperature, touch and movement are essential for our adaptation to the constantly changing surrounding. Prior to the discoveries of David Julius and Ardem Patapoutian, our understanding of how the nervous system senses and interprets our environment still contained a fundamental unsolved question: how are temperature and mechanical stimuli converted into electrical impulses in the nervous system?

In the 17th century, the philosopher René Descartes envisioned threads connecting different parts of the skin with the brain. In this way, a foot touching an open flame would send a mechanical signal to the brain (Figure 1). Discoveries later revealed the existence of specialized sensory neurons that register changes in our environment.

In the latter part of the 1990's, **DAVID JULIUS** at the University of California, San Francisco, USA, saw the possibility for major advances by analysing how the chemical compound **capsaicin** causes the burning sensation we feel when we come into contact with chilli peppers. Capsaicin was already known to activate nerve cells causing pain sensations, but how this chemical actually exerted this function was an unsolved riddle. Julius and his co-workers created a library of millions of DNA fragments corresponding to genes that are expressed in the sensory neurons which can react to pain, heat, and touch.

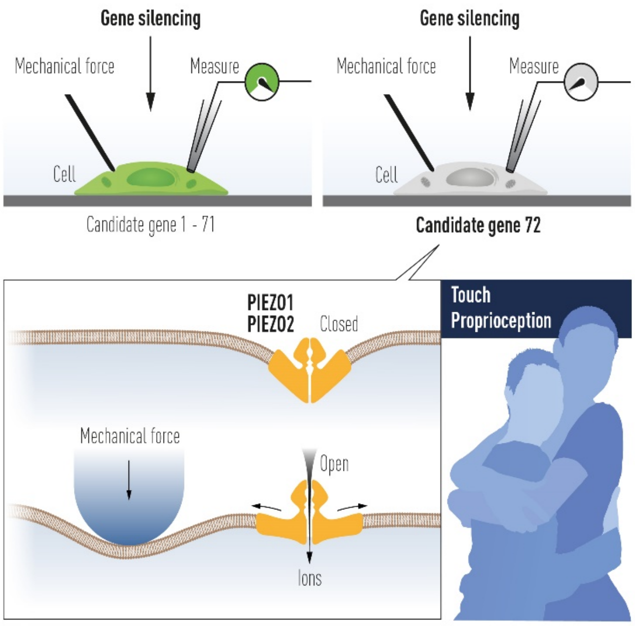
After a laborious search, a single gene was identified that was able to make cells capsaicin sensitive (Figure 2). The gene for capsaicin sensing had been found! Further experiments revealed that the identified gene encoded a novel ion channel protein and this newly discovered capsaicin receptor was later named TRPV1. When Julius investigated the protein's ability to respond to heat, he realized that he had discovered a heat-sensing receptor that is activated at temperatures perceived as painful.

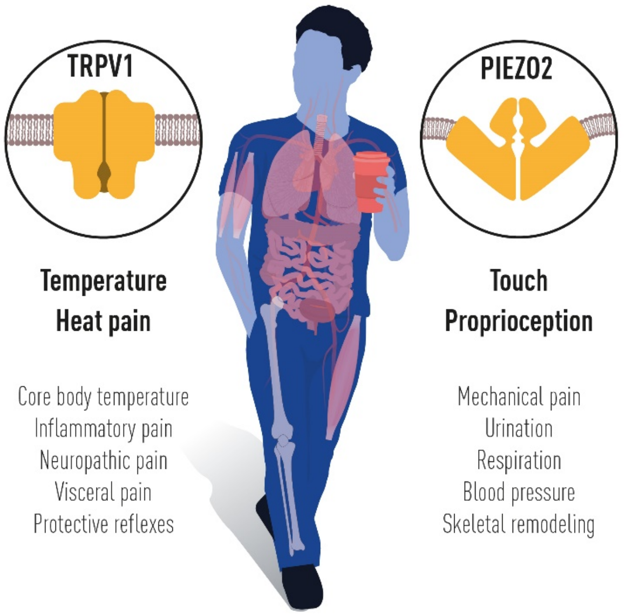


While the mechanisms for temperature sensation were unfolding, it remained unclear how mechanical stimuli could be converted into our senses of touch and pressure. Researchers had previously found mechanical sensors in bacteria, but the mechanisms underlying touch in vertebrates remained unknown. **ARDEM PATAPOUTIAN**, working at Scripps Research in La Jolla, California, USA, wished to identify the elusive receptors that are activated by mechanical stimuli.

Patapoutian and his collaborators first identified a cell line that gave off a measurable electric signal when individual cells were poked with a micropipette. It was assumed that the receptor activated by mechanical force is an ion channel and in a next step 72 candidate genes encoding possible receptors were identified. These genes were inactivated one by one to discover the gene responsible for mechanosensitivity in the studied cells. After an arduous search, Patapoutian and his co-workers succeeded in identifying a single gene whose silencing rendered the cells insensitive to poking with the micropipette. A new and entirely unknown mechanosensitive ion channel had been discovered and was given the name Piezo1, after the Greek word for pressure (í; píesi). Through its similarity to Piezo1, a second gene was discovered and named Piezo2. Sensory neurons were found to express high levels of Piezo2 and further studies firmly established that Piezo1 and Piezo2 are ion channels that are directly activated by the exertion of pressure on cell membranes.

The breakthrough by Patapoutian led to a series of papers from his and other groups, demonstrating that the Piezo2 ion channel is essential for the sense of touch. Moreover, Piezo2 was shown to play a key role in the critically important sensing of body position and motion, known as proprioception. In further work, Piezo1 and Piezo2 channels have been shown to regulate additional important physiological processes including blood pressure, respiration and urinary bladder control.





The ground-breaking discoveries of the TRPV1, TRPM8 and Piezo channels by this year's Nobel Prize laureates have allowed us to understand how heat, cold and mechanical force can initiate the nerve impulses that allow us to perceive and adapt to the world around us. The TRP channels are central for our ability to perceive temperature. The Piezo2 channel endows us with the sense of touch and the ability to feel the position and movement of our body parts. TRP and Piezo channels also contribute to numerous additional physiological functions that depend on sensing temperature or mechanical stimuli. Intensive ongoing research originating from this year's Nobel Prize awarded discoveries focusses on elucidating their functions in a variety of physiological processes.

This knowledge is being used to develop treatments for a wide range of disease conditions, including chronic pain.

https://www.bbc.co.uk/news/health-58787438
https://www.nobelprize.org/prizes/medicine/2021/press-release/

COVID NEWS - Llama Antibodies Have "Significant Potential" As Frontline Treatment

A unique type of tiny antibody produced by llamas could provide a new frontline treatment against Covid-19 that can be taken by patients as a simple nasal spray. Research led by scientists at the Rosalind Franklin Institute has shown that nanobodies – a smaller, simple form of antibody generated by llamas and camels – can effectively target the SARS-CoV-2 virus that causes Covid-19.

The nanobodies, which bind tightly to the SARS-CoV-2 virus, neutralizing it in cell culture, could provide a cheaper and easier to use alternative to human antibodies taken from patients who have recovered from Covid-19. Human antibodies have been a key treatment for serious cases during the pandemic, but typically need to be administered by infusion through a needle in the hospital.

The research team at the Rosalind Franklin Institute (Harwell, UK), whose findings are published in the journal *Nature Communication*, were able to generate the nanobodies by injecting a portion of the SARS-CoV-2 spike protein into a llama called Fifi, who is part of the antibody production facility at the University of Reading.

"Nanobodies have a number of advantages over human antibodies," said Professor Ray Owens, head of protein production at the Rosalind Franklin Institute and lead author of the research. *"They are cheaper to produce and can be delivered directly to the airways through a nebulizer or nasal spray, so can be self-administered at home rather than needing an injection. This could have benefits in terms of ease of use by patients but it also gets the treatment directly to the site of infection in the respiratory tract."*

Llama Antibodies Have "Significant Potential" As Frontline COVID-19 Treatment – Simple Nasal Spray (scitechdaily.com)

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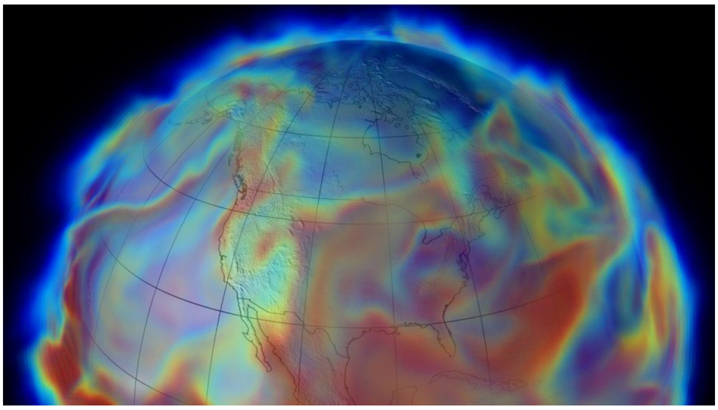


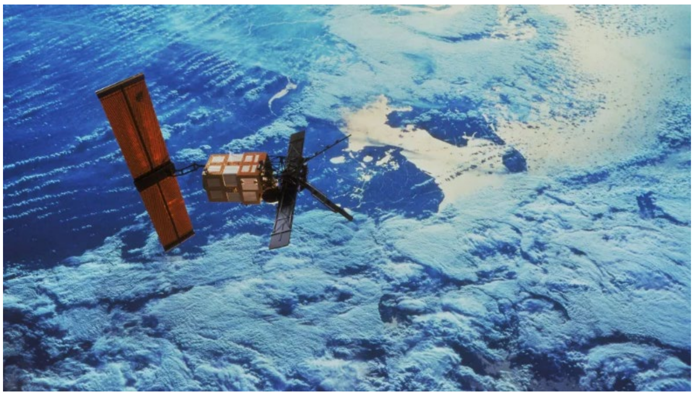
Complex systems are characterised by randomness and disorder and are difficult to understand. This year's Prize recognises new methods for describing them and predicting their long-term behaviour.

One complex system of vital importance to humankind is Earth's climate. Syukuro Manabe demonstrated how increased levels of carbon dioxide in the atmosphere lead to increased temperatures at the surface of the Earth. In the 1960s, he led the development of physical models of the Earth's climate and was the first person to explore the interaction between radiation balance and the vertical transport of air masses. His work laid the foundation for the development of current climate models.

About ten years later, Klaus Hasselmann created a model that links together weather and climate, thus answering the question of why climate models can be reliable despite weather being changeable and chaotic. He also developed methods for identifying specific signals, fingerprints, that both natural phenomena and human activities imprint in the climate. His methods have been used to prove that the increased temperature in the atmosphere is due to human emissions of carbon dioxide.

Around 1980, Giorgio Parisi discovered hidden patterns in disordered complex materials. His discoveries are among the most important contributions to the theory of complex systems. They make it possible to understand and describe many different and apparently entirely random materials and phenomena, not only in physics but also in other, very different areas, such as mathematics, biology, neuroscience and machine learning.

"The discoveries being recognised this year demonstrate that our knowledge about the climate rests on a solid scientific foundation, based on a rigorous analysis of observations. This year's Laureates have all contributed to us gaining deeper insight into the properties and evolution of complex physical systems," says Thors Hans Hansson, chair of the Nobel Committee for Physics.



Hasselman, now 89 and still active at the Max Planck Institute for Meteorology in Germany, was also a member of an expert group that, in the 1970s, helped the European Space Agency (ESA) create its Earth observation program and build its first mission dedicated to studying Earth from above. As a member of the space agency's High-Level Earth Observation Advisory Committee, Hasselman contributed to the development of the European Remote Sensing satellite (ERS-1) and its successor ERS-2.

For ERS-2, Hasselmann developed a method for measuring ocean waves using synthetic aperture radar (SAR) imaging, ESA said in the statement. SAR instruments send a signal to the ground and then measure how much of it is reflected back. These instruments are increasingly employed by environment-monitoring satellites today and the technique developed by Hasselmann is still in use on current Earth-observing satellites such as the European Copernicus Sentinel-1 radar mission.

https://www.bbc.co.uk/news/science-environment-58790160
https://www.nobelprize.org/prizes/physics/2021/press-release/

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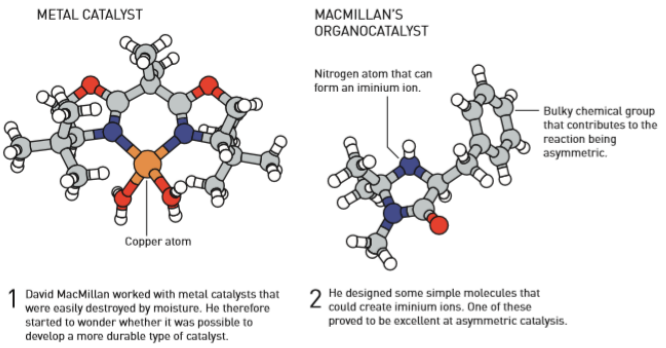
Many research areas and industries are dependent on chemists' ability to construct molecules that can form elastic and durable materials, store energy in batteries or inhibit the progression of diseases. This work requires **catalysts**, which are substances that control and accelerate chemical reactions, without becoming part of the final product. For example, catalysts in cars transform toxic substances in exhaust fumes to harmless molecules. Our bodies also contain thousands of catalysts in the form of enzymes, which chisel out the molecules necessary for life.



©Johan Jarnestad/The Royal Swedish Academy of Sciences

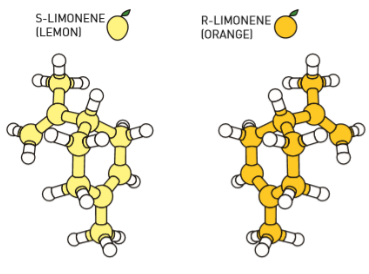
Catalysts are thus fundamental tools for chemists, but researchers long believed that there were, in principle, just two types of catalysts available: metals and enzymes. Benjamin List and David MacMillan are awarded the Nobel Prize in Chemistry 2021 because in 2000 they, independent of each other, developed a **third type of catalysis**. It is called asymmetric organocatalysis and builds upon small organic molecules. *"This concept for catalysis is as simple as it is ingenious, and the fact is that many people have wondered why we didn't think of it earlier,"* says Johan Åqvist, who is chair of the Nobel Committee for Chemistry.

Organocatalysis has developed at an astounding speed since 2000. Benjamin List and David MacMillan remain leaders in the field, and have shown that organic catalysts can be used to drive multitudes of chemical reactions. Using these reactions, researchers can now more efficiently construct anything from new pharmaceuticals to molecules that can capture light in solar cells. In this way, organocatalysts are bringing the greatest benefit to humankind.

The discovery has taken molecular construction to an entirely new level. It has not only made chemistry greener, but also made it much easier to produce asymmetric molecules. During chemical construction a situation often arises in which two molecules can form, which – just like our hands – are each other's mirror image. Chemists often just want one of these mirror images, particularly when producing pharmaceuticals, but it has been difficult to find efficient methods for doing this. The concept developed by Benjamin List and David MacMillan – asymmetric organocatalysis – is as simple as it is brilliant. The fact is that many people have wondered why we didn't think of it earlier!

A good example of a "mirror image" molecule, and how one can differ significantly from the other in its properties, is **LIMONENE**. We are all familiar with this compound, as it is the basis of the distinctive, aromatic scent we get from citrus fruits. It is named after the French for lemon, *limon*.

However, this begs the question: **why do lemons and oranges smell differently** if limonene is the cause of the smell? The answer lies in the fact that the limonene molecule can exist in two "mirror image" forms (see diagram). The "S-form" gives us the lemony smell, while it is the "R-form" that gives us the orangey smell.



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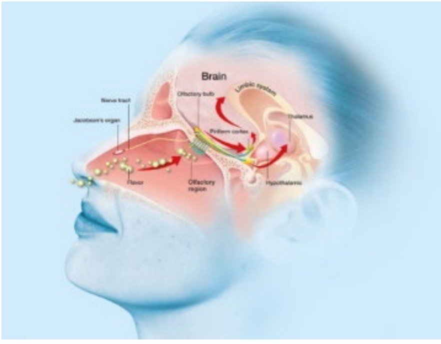
One example of how organocatalysis has led to more efficient molecular constructions is the synthesis of the natural, and astoundingly complex, **strychnine** molecule. Many people will recognise strychnine from books by Agatha Christie, queen of the murder mystery. However, for chemists, strychnine is like a Rubik's Cube: a challenge that you want to solve in as few steps as possible. When strychnine was first synthesised, in 1952, it required 29 different chemical reactions and only 0.0009 per cent of the initial material formed strychnine. The rest was wasted. In 2011, researchers were able to use organocatalysis and a cascade reaction to build strychnine in just 12 steps, and the production process was 7,000 times more efficient.

https://www.bbc.co.uk/news/science-environment-58814418
https://www.nobelprize.org/prizes/chemistry/2021/press-release/

THE FOLLOWING ITEM WAS SPOTTED BY Dr R DAVIES

COGNITIVE SCIENCE - Smelling fear? Study provides evidence that chemosensory anxiety signals reduce trust and risk-taking in women



The odour of anxiety-induced body sweat can make women become more risk adverse and less trusting of others, according to new research published in the journal *Biological Psychology*. The new findings indicate that chemosensory anxiety signals can act contagiously but predominantly affect women.

We all know that 'clammy' feeling we get when we are under stress. The latest research provides evidence that stress can be communicated between individuals via chemosensory cues hidden in the odour we emit.

"Most intriguing for me is that people communicate their motivational and emotional state via sweat derived chemosignals, but without being conscious about this process. Meanwhile, we know a lot about the brains' response to these chemosignals but much less about effects on overt behaviour. That's why this study was very important to me," said study author Bettina M. Pause, a psychology professor at Heinrich-Heine-University Düsseldorf.

The researchers conducted a series of five studies with 159 non-smoking women and 55 non-smoking men to examine whether chemosensory anxiety signals reduced trust and risk behaviour. An experimentally-verified task known as The Trust Game was used to measure trustworthiness. In the game, one participant is given a small amount of money and then chooses how much he or she wants to transfer to a fictional co-player (the trustee). Any amount of money that is invested is then tripled. The participants are told that the trustee will subsequently decide how much of this money to give back.

To assess the willingness to take risks, the researchers also used a variant of The Trust Game (known as The Risk Game) in which participants were told the co-player was a computer and the amount of money retransferred back to them after the initial investment would be random.

As they played through multiple trials of either game, the participants were exposed to various odours just before they had to decide how much money to invest. The odours included sweat that was collected from men experiencing anxiety during a Trier Social Stress Test and sweat collected from men during mild exercise. The participants wore a hospital oxygen mask that was hooked up to an olfactometer, allowing the researchers to precisely control the level of odour the participants were exposed to.

The researchers found that women tended to transfer less money after being exposed to chemosensory anxiety signals compared to the other odours. This was true even when the odour from anxiety-induced sweat was not consciously detectable.

https://www.psypost.org/2021/09/smelling-fear-study-provides-evidence-that-chemosensory-anxiety-signals-reduce-trust-and-risk-taking-in-women-61842

WEIRD SCIENCE - Cows don't just moo – they also talk about the weather, say scientists

We all like to imitate the moo of a cow, but rather than just being a random, indiscriminate bovine sound, it could be that cows are communicating with each other. And, rather like humans, they talk about food and the weather!

A new study says that cows have their own language and can talk to each other about food and the weather. Researchers, led by a Ph.D. candidate from the University of Sydney, discovered that dairy cows have their own individual voice and they respond to positive and negative emotional situations. The team of researchers created a software program that they dubbed "Google Translate for cows" to get a better idea of what the animals are saying when they moo. They did this by listening to Holstein-Friesian heifers, a European breed, mooing into a microphone and analysing their pitch.

They also found that each animal retains its own distinct moo and can give cues in different situations to maintain contact with the rest of the herd. They are said to be able to express excitement, arousal, engagement, and distress as well.

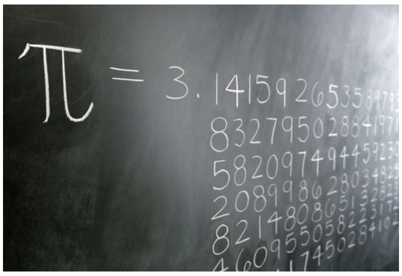
The findings could help farmers keep their cattle healthy by understanding their moods and translating their individual sounds.

Cows do not just moo – they also talk about the weather, say scientists (weirdsciencenews.com)

MAD MATHS! - Pi (π) calculated to a record-breaking 62.8 trillion digits

Because its most elementary definition (the ratio between a circle's circumference and its diameter) relates to the circle, Pi (π) is found in many formulae in trigonometry and geometry, especially those concerning circles, ellipses, and spheres. We can trace this ratio back to the ancient civilisations of Babylonia, Egypt, Greece and India. Although Pi (π) is a letter of the Greek alphabet, it was not used as the symbol for the mathematical value until 1706 and the Welsh mathematician William Jones.

The early approximations of Pi were fairly crude, such as the fraction 22/7, but they were good enough for purposes at the time. With the invention of calculus in the 17th century, Pi's value began to be determined to ever increasing numbers of decimal places. With the advent of modern, digital computers throughout the second half of the 20th century, it became possible to calculate Pi to millions and even trillions of decimal places.



In August this year, researchers from the University of Applied Sciences of the Grisons in Switzerland announced that they had broken the record for the most accurate value of pi by more than 12 trillion decimal places, using a computer at the Competence Centre for Data Analysis, Visualization and Simulation (DAViS). The record attempt has yet to be officially confirmed by Guinness World Records. Using a supercomputer to run an established algorithm for calculating Pi, it took the DAViS team 108 days and 9 hours to reach 62.8 trillion digits.

The overriding question is: **WHY!** Especially given that the number of digits for Pi has little importance.

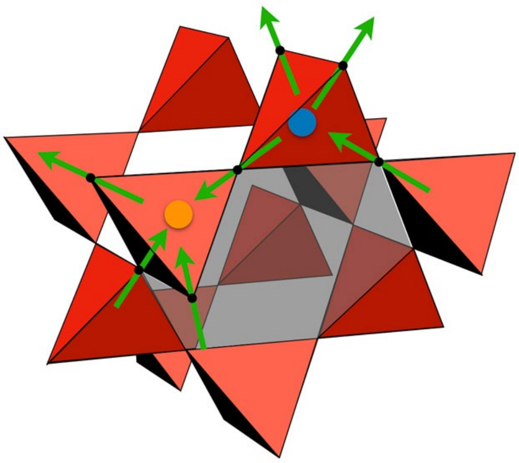
"Breaking the record is just a side effect of our work in preparing our high performance computer infrastructure for work in research and development," lead researcher Thomas Keller, a computer scientist at the University of Applied Sciences of the Grisons, said. Calculating the value of Pi to high precision has long been used as a benchmark to test the processing power of computers. In 2019, a Google cloud computing system calculated the constant's value to more than 31 trillion decimal places, and in 2020, Timothy Mullican of Huntsville, Alabama, founder of a non-profit called North Alabama Charitable Computing, calculated 50 trillion decimal places, using his personal computer – it took him over 300 days!

https://www.livescience.com/record-number-of-pi-digits.html

QUANTUM PHYSICS - One of nature's key constants is much larger in a quantum material

In the strange world of quantum physics where particles can be in two places at once and if a cat is enclosed in a box it could be both alive and dead at the same time, there is also a theory that our universe might not be "uni" at all, but one of many. Theoretical physicists think they may have found a clue to these alternative universes.

In work published recently in the journal *Physical Letters Review*, physicists from Germany, USA and UK have looked at something called the **fine-structure constant** and calculate that it is 10 times its normal value in a type of material called **quantum spin ice**. The new calculation hints that quantum spin ice could give a glimpse at physics within an alternate universe where the constant is much larger.



The fine-structure constant sets the strength of interactions between electrically charged particles and its influence is in both physics and chemistry. It can be used to explain how and why chemical elements react together in the way that they do. Indeed, how living things such as ourselves can evolve. This new calculation of the constant in quantum spin ice has caused some consternation – *"If the fine-structure constant throughout the cosmos were as large as the one in quantum spin ices, the periodic table would only have 10 elements,"* says theoretical physicist Christopher Laumann of Boston University. *"And it probably would be hard to make people; there wouldn't be enough richness to chemistry."*

Unfortunately, scientists haven't yet found a material that definitively qualifies as quantum spin ice! But one much-studied prospect is a group of minerals called pyrochlores, which have magnetic ions, or electrically charged atoms, arranged in a pyramid configuration. Scientists might also be able to study the materials using a quantum computer or another quantum device designed to simulate quantum spin ices.

If scientists ever succeed in creating quantum spin ice, the materials could reveal how quantum electrodynamics and the standard model of physics would work in a universe with a much larger fine-structure constant. Then we really would have an insight into another universe.

https://www.sciencenews.org/article/physics-quantum-spin-ice-fine-structure-constant

WORD(S) OF THE MONTH:

MOLECULE (noun, *"MOL-eh-KEWL"*)

A general definition is as follows: *"A group of two or more atoms that form the smallest identifiable unit into which a pure substance can be divided and still retain the composition and chemical properties of that substance."* A more strictly scientific definition would be *"An electrically neutral group of two or more atoms held together by chemical bonds. Molecules are distinguished from ions by their lack of electrical charge."*

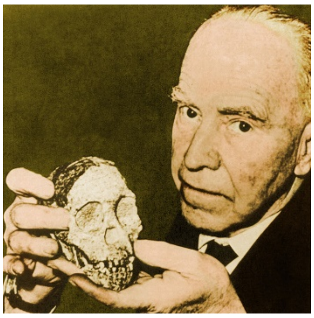
Atoms consist of a single nucleus with a positive charge surrounded by a cloud of negatively charged electrons. When atoms approach one another closely, the electron clouds interact with each other and with the nuclei. If this interaction is such that the total energy of the system is lowered, then the atoms bond together to form a molecule. Thus, from a structural point of view, a molecule consists of an aggregation of atoms held together by valence forces.

The molecular weight of a molecule is the sum of the atomic weights of its component atoms. If a substance has molecular weight M, then M grams of the substance is termed one mole. The number of molecules in one mole is the same for all substances; this number is known as Avogadro's number ($6.022140857 \times 10^{23}$)

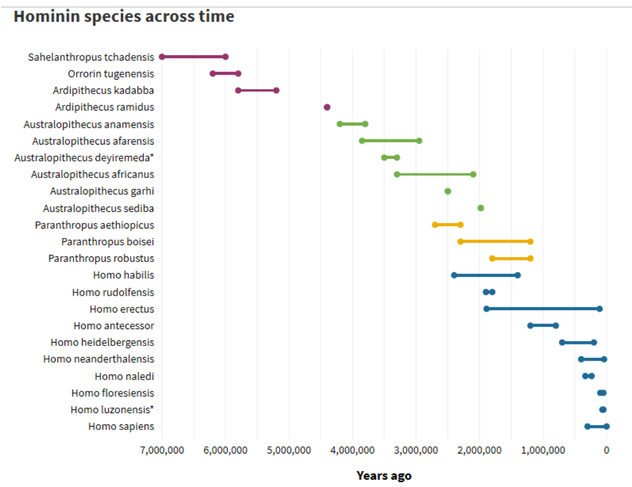
https://www.britannica.com/science/molecule

PALAEOANTHROPOLOGY - Fossils and ancient DNA paint a vibrant picture of human origins

A century of science has begun to explain how and where ***Homo sapiens*** and our kin evolved. In *The Descent of Man*, published in 1871, Charles Darwin hypothesised that our ancestors came from Africa. He pointed out that among all animals, the African apes — gorillas and chimpanzees — were the most similar to humans. But he had little fossil evidence. The few known human fossils had been found in Europe, and those that trickled in over the next 50 years came from Europe and from Asia. It was generally assumed at the time that Darwin had got it wrong about our origins being in Africa.



Finally, in 1924, a fortuitous find supported Darwin's speculation. Among the debris at a limestone quarry in South Africa, miners recovered the fossilised skull of a toddler. Based on the child's blend of humanlike and apelike features an anatomist, Raymond Dart, determined that the fossil was what was then popularly known as a "missing link." It was the most apelike fossil yet found of a hominid — that is, a member of the family *Hominidae*, which includes modern humans and all our close, extinct relatives. It has become known as the **Taung Child**. Since that discovery, paleoanthropologists have amassed many thousands of fossils, and the evidence over and over again has pointed to Africa as our place of origin. Genetic studies reinforce that story. African apes are indeed our closest living relatives, with chimpanzees more closely related to us than to gorillas. In fact, many scientists now include great apes in the hominid family, using the narrower term "hominin" to refer to humans and our extinct cousins.



In a field with a reputation for bitter feuds and rivalries, the notion of humankind's African origins unifies human evolution researchers. *"I think everybody agrees and understands that Africa was very pivotal in the evolution of our species,"* says Charles Musiba, a paleoanthropologist at the University of Colorado Denver (US). Paleoanthropologists have sketched a rough timeline of how that evolution played out. Sometime between 9 million and 6 million years ago, the first hominins evolved. Walking upright on two legs distinguished our ancestors from other apes; our ancestors also had smaller canine teeth, perhaps a sign of less aggression and a change in social interactions. Between about 3.5 million and 3 million years ago, humankind's forerunners ventured beyond wooded areas. Africa was growing drier, and grasslands spread across the continent. Hominins were also crafting stone tools by this time. The human genus, *Homo*, arrived between 2.5 million and 2 million years ago, maybe earlier, with larger brains than their predecessors. By at least 2 million years ago, *Homo* members started traveling from Africa to Eurasia. By about 300,000 years ago, *Homo sapiens* emerged.

It is premature to pen a comprehensive explanation of human evolution with so much ground in Africa and elsewhere to explore. Our origin story is still a work in progress. However, modern analysis, especially using DNA, provides powerful evidence that hominins did indeed arise on the African continent.

https://www.sciencenews.org/article/human-evolution-species-origin-fossils-ancient-dna