# St Benedict's SCIENCE NEWS *Monthly*

## Welcome to the November 2023 issue

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

# SPECIAL NOBEL PRIZE EDITION

Every year, in the first weeks of October, a very few lucky scientists, authors and economists get a phone call. For some, the phone rings in the middle of the night. For others, the middle of the day. On the other end of the line is someone with a Swedish accent who informs them they have won a Nobel Prize. Almost instantly, these individuals become celebrities. They will give talks, go to fancy parties and meet the King of Sweden. But why is it such a big deal?

The awards are named for an inventor, **Alfred Nobel**. During his life, this man was best known for inventing dynamite, a type of explosive. It made him a wealthy man. And when he died in 1896, Nobel left money from his fortune to establish five yearly awards — the Nobel Prizes.


Nobel's will directed that one award go to recognize outstanding literature. Another should reward the fostering of international peace. Nobel also wanted to reward scientific discovery. So three awards would celebrate discoveries or inventions in physics, chemistry and physiology or medicine. Later, an award for contributions to Economic Science was introduced. All six awards would come with a cash prize. That prize is now about 10 million Swedish krona (around £800,000, depending on the exchange rate in any given year). If there are more than one winner in a category, they split the money equally.

The first set of Nobel Prizes was handed out in 1901. Now, the Nobel Prize *"is reckoned the world championship of science. It's the most prestigious prize worldwide,"* says Nils Hansson. He is a medical historian at the Heinrich-Heine University in Dusseldorf, Germany. Winners, he notes, *"are celebrated like stars, and their research gets a lot of attention."* The prize is also notable for being international. These awards can go to scientists anywhere, not just in Nobel's home country of Sweden.

However, there has been (and still is!) criticism of the Nobel committee for the lack of diversity among those to whom Prizes are awarded. Between 1901 and 2018, only 12 of the 211 total winners in physiology or medicine have been women. Only five women over that period have ever won the Nobel Prize in chemistry. Just three have won it in physics. For minority scientists, the numbers are even worse. No black scientist has ever taken home a Nobel Prize.

But things are changing: Important scientific societies, such as the National Academy of Sciences in the United States and the Royal Society in the United Kingdom, now let in more women and people of colour. These societies help scientists get recognized by their peers. And the more women and minorities that become recognized, the more likely they are to receive a Nobel Prize. Between 1901 and 2001, only 10 women received a Nobel Prize in science. Within the next 15 years, another eight won them. That is still not entirely fair, but it is certainly better than it was.

Another thing the Nobel committee might have to address is that it only gives awards in three areas of science, whereas science has broadened considerably into many different disciplines that produce ground-breaking theoretical and practical work.

**This year's prize winners are featured in this month's Science News.**

## The award for **PHYSIOLOGY OR MEDICINE** was awarded to **KATALIN KARIKO** and **DREW WEISSMAN** on Oct. 2, for their discoveries that led to the development of effective mRNA vaccines against Covid-19.

The discoveries by the two Nobel Laureates were critical for developing effective mRNA vaccines against COVID-19 during the pandemic that began in early 2020. Through their groundbreaking findings, which have fundamentally changed our understanding of how mRNA interacts with our immune system, the laureates contributed to the unprecedented rate of vaccine development during one of the greatest threats to human health in modern times.

### VACCINES BEFORE THE PANDEMIC

Vaccination stimulates the formation of an immune response to a particular pathogen. This gives the body a head start in the fight against disease in the event of a later exposure. Vaccines based on killed or weakened viruses have long been available, exemplified by the vaccines against polio, measles, and yellow fever. In 1951, Max Theiler was awarded the Nobel Prize in Physiology or Medicine for developing the yellow fever vaccine.

Thanks to the progress in molecular biology in recent decades, vaccines based on individual viral components, rather than whole viruses, have been developed. Parts of the viral genetic code, usually encoding proteins found on the virus surface, are used to make proteins that stimulate the formation of virus-blocking antibodies. Examples are the vaccines against the hepatitis B virus and human papillomavirus. Alternatively, parts of the viral genetic code can be moved to a harmless carrier virus, a “vector.” This method is used in vaccines against the Ebola virus. When vector vaccines are injected, the selected viral protein is produced in our cells, stimulating an immune response against the targeted virus.

Producing whole virus-, protein- and vector-based vaccines requires large-scale cell culture. This resource-intensive process limits the possibilities for rapid vaccine production in response to outbreaks and pandemics. Therefore, researchers have long attempted to develop vaccine technologies independent of cell culture, but this proved challenging.

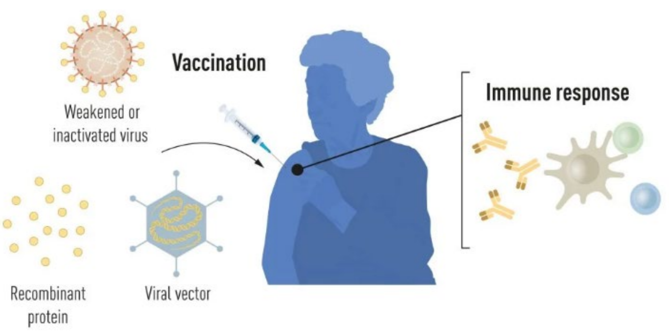



Illustration of methods for vaccine production before the COVID-19 pandemic.

Figure 1. Methods for vaccine production before the COVID-19 pandemic. © The Nobel Committee for Physiology or Medicine. Ill. Mattias Karlén

### mRNA VACCINES: A PROMISING IDEA

In our cells, genetic information encoded in DNA is transferred to messenger RNA (mRNA), which is used as a template for protein production. During the 1980s, efficient methods for producing mRNA without cell culture were introduced, called in vitro transcription. This decisive step accelerated the development of molecular biology applications in several fields. Ideas of using mRNA technologies for vaccine and therapeutic purposes also took off, but roadblocks lay ahead. In vitro transcribed mRNA was considered unstable and challenging to deliver, requiring the development of sophisticated carrier lipid systems to encapsulate the mRNA. Moreover, in vitro-produced mRNA gave rise to inflammatory reactions. Enthusiasm for developing the mRNA technology for clinical purposes was, therefore, initially limited.

These obstacles did not discourage the Hungarian biochemist Katalin Karikó, who was devoted to developing methods to use mRNA for therapy. During the early 1990s, when she was an assistant professor at the University of Pennsylvania, she remained true to her vision of realizing mRNA as a therapeutic despite encountering difficulties in convincing research funders of the significance of her project. A new colleague of Karikó at her university was the immunologist Drew Weissman. He was interested in dendritic cells, which have important functions in immune surveillance and the activation of vaccine-induced immune responses. Spurred by new ideas, a fruitful collaboration between the two soon began, focusing on how different RNA types interact with the immune system.

### THE BREAKTHROUGH

Karikó and Weissman noticed that dendritic cells recognize in vitro transcribed mRNA as a foreign substance, which leads to their activation and the release of inflammatory signalling molecules. They wondered why the in vitro transcribed mRNA was recognized as foreign while mRNA from mammalian cells did not give rise to the same reaction. Karikó and Weissman realized that some critical properties must distinguish the different types of mRNA.

RNA contains four bases, abbreviated A, U, G, and C, corresponding to A, T, G, and C in DNA, the letters of the genetic code. Karikó and Weissman knew that bases in RNA from mammalian cells are frequently chemically modified, while in vitro transcribed mRNA is not. They wondered if the absence of altered bases in the in vitro transcribed RNA could explain the unwanted inflammatory reaction. To investigate this, they produced different variants of mRNA, each with unique chemical alterations in their bases, which they delivered to dendritic cells. The results were striking: The inflammatory response was almost abolished when base modifications were included in the mRNA. This was a paradigm change in our understanding of how cells recognize and respond to different forms of mRNA. Karikó and Weissman immediately understood that their discovery had profound significance for using mRNA as therapy. These seminal results were published in 2005, fifteen years before the COVID-19 pandemic.

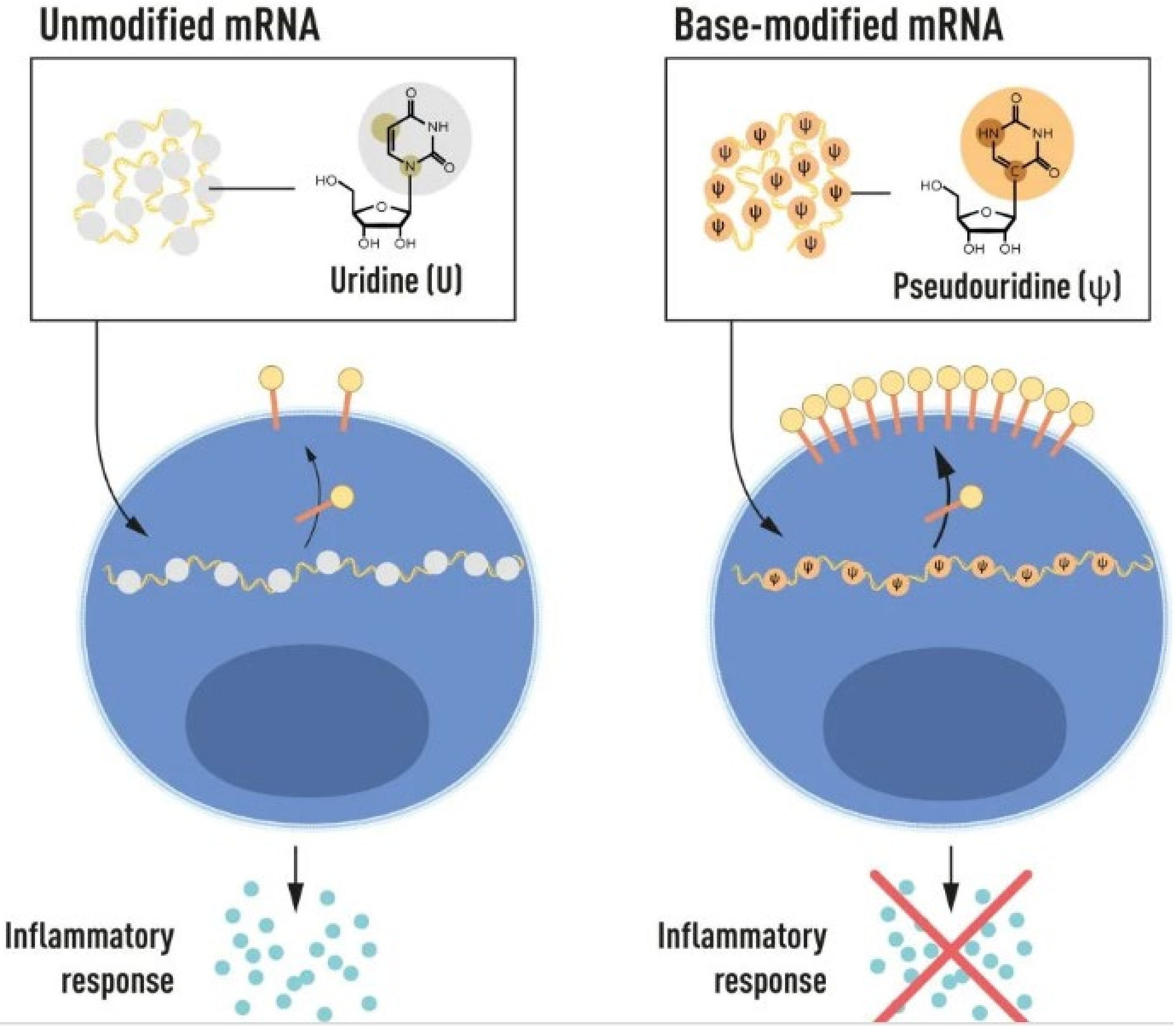



Figure 2. mRNA contains four different bases, abbreviated A, U, G, and C. The Nobel Laureates discovered that base-modified mRNA can be used to block activation of inflammatory reactions (secretion of signalling molecules) and increase protein production when mRNA is delivered to cells. © The Nobel Committee for Physiology or Medicine. Ill. Mattias Karlén

## mRNA VACCINES REALIZED THEIR POTENTIAL

Interest in mRNA technology began to pick up, and in 2010, several companies were working on developing the method. Vaccines against Zika virus and MERS-CoV were pursued; the latter is closely related to SARS-CoV-2. After the outbreak of the COVID-19 pandemic, two base-modified mRNA vaccines encoding the SARS-CoV-2 surface protein were developed at record speed. Protective effects of around 95% were reported, and both vaccines were approved as early as December 2020.

The impressive flexibility and speed with which mRNA vaccines can be developed pave the way for using the new platform also for vaccines against other infectious diseases. In the future, the technology may also be used to deliver therapeutic proteins and treat some cancer types.

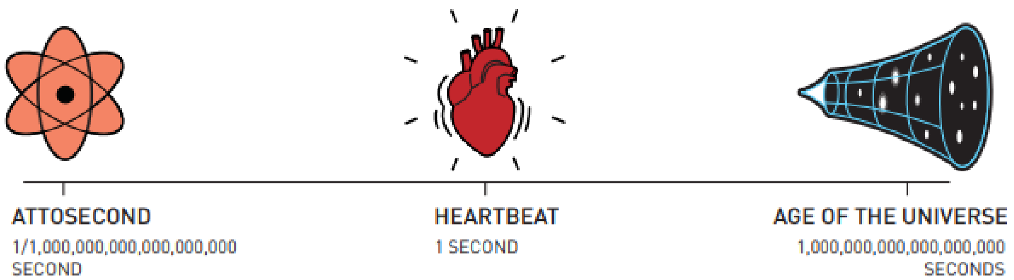
Several other vaccines against SARS-CoV-2, based on different methodologies, were also rapidly introduced, and together, more than 13 billion COVID-19 vaccine doses have been given globally. The vaccines have saved millions of lives and prevented severe disease in many more, allowing societies to open and return to normal conditions. Through their fundamental discoveries of the importance of base modifications in mRNA, this year's Nobel laureates critically contributed to this transformative development during one of the biggest health crises of our time.

## On October 3 the award for **PHYSICS** was shared by three scientists — **PIERRE AGOSTINI**, **FERENC KRAUSZ** and **ANNE L'HUILLIER** — for their work on electrons.

### EXPERIMENTS WITH LIGHT CAPTURE THE SHORTEST OF MOMENTS

The three Nobel Laureates in Physics 2023 are being recognised for their experiments, which have given humanity new tools for exploring the world of electrons inside atoms and molecules. Pierre Agostini, Ferenc Krausz and Anne L'Huillier have demonstrated a way to create extremely short pulses of light that can be used to measure the rapid processes in which electrons move or change energy.

Fast-moving events flow into each other when perceived by humans, just like a film that consists of still images is perceived as continual movement. If we want to investigate really brief events, we need special technology. In the world of electrons, changes occur in a few tenths of an **attosecond** – an attosecond is so short that there are as many in one second as there have been seconds since the birth of the universe. The laureates' experiments have produced pulses of light so short that they are measured in attoseconds, thus demonstrating that these pulses can be used to provide images of processes inside atoms and molecules.

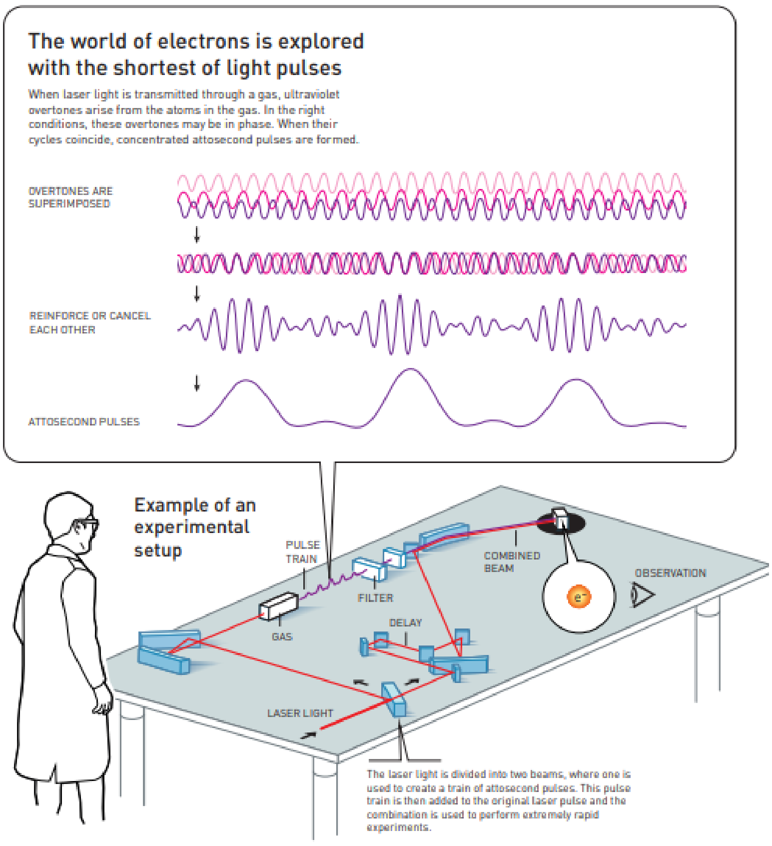



Electrons' movements in atoms and molecules are so rapid that they are measured in attoseconds. An attosecond is to one second as one second is to the age of the universe.



In 1987, Anne L'Huillier discovered that many different overtones of light arose when she transmitted infrared laser light through a noble gas. Each overtone is a light wave with a given number of cycles for each cycle in the laser light. They are caused by the laser light interacting with atoms in the gas; it gives some electrons extra energy that is then emitted as light. Anne L'Huillier has continued to explore this phenomenon, laying the ground for subsequent breakthroughs.

In 2001, Pierre Agostini succeeded in producing and investigating a series of consecutive light pulses, in which each pulse lasted just 250 attoseconds. At the same time, Ferenc Krausz was working with another type of experiment, one that made it possible to isolate a single light pulse that lasted 650 attoseconds.



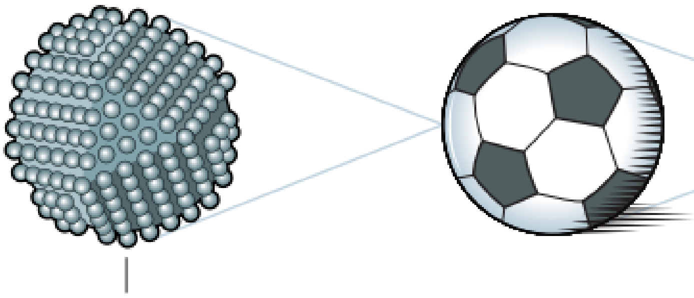



The laureates' contributions have enabled the investigation of processes that are so rapid they were previously impossible to follow. *"We can now open the door to the world of electrons. Attosecond physics gives us the opportunity to understand mechanisms that are governed by electrons. The next step will be utilising them,"* says Eva Olsson, Chair of the Nobel Committee for Physics. There are potential applications in many different areas. In electronics, for example, it is important to understand and control how electrons behave in a material. Attosecond pulses can also be used to identify different molecules, such as in medical diagnostics.

# The award for **CHEMISTRY** went on October 4 to **MOUNGI G. BAWENDI, LOUIS E. BRUS** and **ALEXEI I. EKIMOV** for the discovery and development of quantum dots, nanoparticles so small that their size determines their properties.

## THEY PLANTED AN IMPORTANT SEED FOR NANOTECHNOLOGY

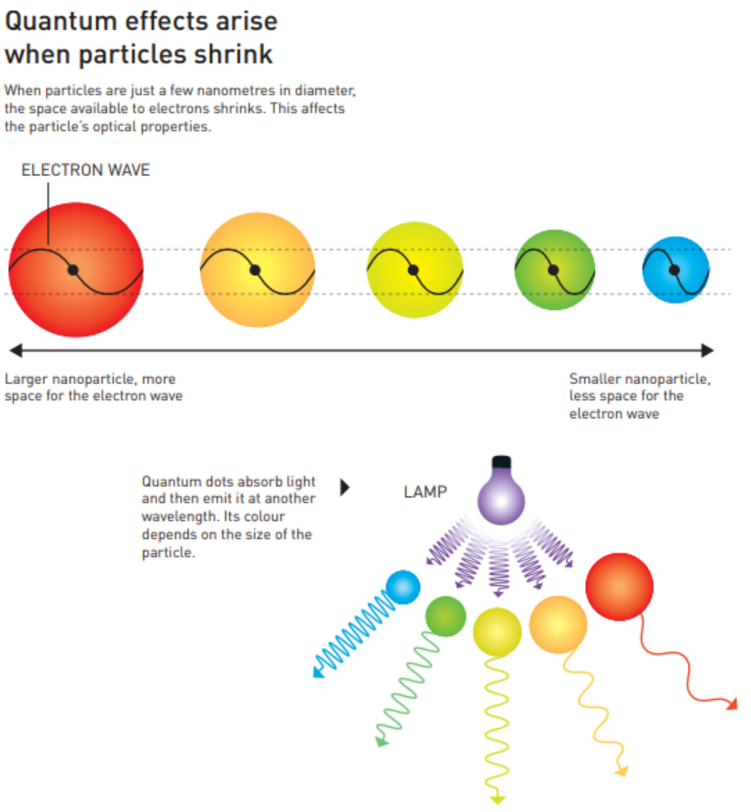
The Nobel Prize in Chemistry 2023 rewards the discovery and development of quantum dots, nanoparticles so tiny that their size determines their properties. These smallest components of nanotechnology now spread their light from televisions and LED lamps, and can also guide surgeons when they remove tumour tissue, among many other things.



A quantum dot is a crystal that often consists of just a few thousand atoms. In terms of size, it has the same relationship to a football as a football has to the size of the Earth.



Everyone who studies chemistry learns that an element's properties are governed by how many electrons it has. However, when matter shrinks to nano-dimensions *quantum phenomena* arise; these are governed by the size of the matter. The Nobel Laureates in Chemistry 2023 have succeeded in producing particles so small that their properties are determined by quantum phenomena. The particles, which are called quantum dots, are now of great importance in nanotechnology.






*"Quantum dots have many fascinating and unusual properties. Importantly, they have different colours depending on their size,"* says Johan Åqvist, Chair of the Nobel Committee for Chemistry.

Physicists had long known that in theory size-dependent quantum effects could arise in nanoparticles, but at that time it was almost impossible to sculpt in nanodimensions. Therefore, few people believed that this knowledge would be put to practical use. However, in the early 1980s, Alexei Ekimov succeeded in creating size-dependent quantum effects in coloured glass. The colour came from nanoparticles of copper chloride and Ekimov demonstrated that the particle size affected the colour of the glass via quantum effects.

A few years later, Louis Brus was the first scientist in the world to prove size-dependent quantum effects in particles floating freely in a fluid.

In 1993, Moungi Bawendi revolutionised the chemical production of quantum dots, resulting in almost perfect particles. This high quality was necessary for them to be utilised in applications.

Quantum dots now illuminate computer monitors and television screens based on QLED technology. They also add nuance to the light of some LED lamps, and biochemists and doctors use them to map biological tissue. Quantum dots are thus bringing the greatest benefit to humankind. Researchers believe that in the future they could contribute to flexible electronics, tiny sensors, thinner solar cells and encrypted quantum communication – so we have just started exploring the potential of these tiny particles.

## The Nobel Prize in **LITERATURE** 2023 was awarded to **JON FOSSE**, *"for his innovative plays and prose which give voice to the unsayable".*

Fosse has written about 40 plays, in addition to numerous short stories, novels, children's books, essays, and poetry. His 2021 work ***A New Name: Septology VI-VII*** has been described as Fosse's "magnum opus" and was a finalist for the International Booker Prize in 2022.

In a 2022 interview with the Los Angeles Review of Books, Fosse said, *"When I manage to write well, there is a second, silent language. This silent language says what it is all about. It's not the story, but you can hear something behind it — a silent voice speaking."*

Fosse's cultural significance in Norway is so huge that there is even a hotel suite named after him in Oslo.

## The Norwegian Nobel Committee awarded the 2023 **PEACE PRIZE** to jailed Iranian activist **NARGES MOHAMMADI**, *"for her fight against the oppression of women in Iran and her fight to promote human rights and freedom for all."*

Mohammadi is the deputy head of the Defenders of Human Rights Center, a non-governmental organization led by 2003 Nobel Peace Prize laureate Shirin Ebadi.

In September 2022 a young Kurdish woman named Mahsa Jina Amini was killed under custody of the Iranian morality police. Her death sparked the largest political demonstration against Iran's theocracy since it came into power in 1979. Thousands of Iranians took to the streets in peaceful protests under the slogan Woman – Life – Freedom. At least 20,000 protestors were jailed, thousands were injured, and 500 demonstrators were killed when the regime cracked down on the protests.

The committee said that the Woman – Life – Freedom motto suitably expresses the dedication and work of Narges Mohammadi. She is serving multiple sentences in Evin Prison in Tehran, amounting to roughly 12 years behind bars.

## The Nobel Memorial Prize in **ECONOMIC SCIENCES** was awarded to Harvard professor **CLAUDIA GOLDIN** for providing the first comprehensive account of *"women's earnings and labour market participation through the centuries,"* which includes intensive research of on the gender pay gap.

Goldin is the third woman to ever receive the Nobel Prize in Economics, and the first one to win the award solo.

*"Understanding women's role in the labour is important for society. Thanks to Claudia Goldin's groundbreaking research we now know much more about the underlying factors and which barriers may need to be addressed in the future,"* said Jakob Svensson, Chair of the Committee for the Prize in Economic Sciences.

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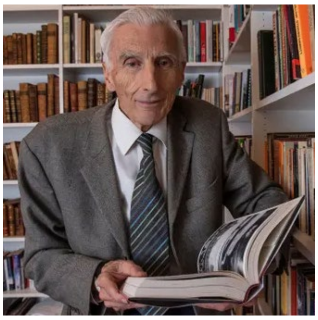
# SOME NOBEL WINNERS ARE GREAT INTELLECTS, OTHERS ARE JUST LUCKY. THERE'S MORE TO SCIENCE THAN THESE PRIZES.

**So says the Astronomer Royal, Martin Rees.**



**Every October sees the award of the "scientific Oscars": Nobel prizes. The science prizes established in Alfred Nobel's will are for physics, chemistry and "physiology or medicine". This year the three scientific Nobels went to a total of eight scientists – rewarded for sustained efforts to tackle fundamental challenges. There will be special acclaim for the Hungarian medical researcher, Katalin Karikó, who persevered, despite much discouragement from her university, on the groundwork that led to several Covid vaccines.**

**These three subjects are interpreted broadly, and their purview has shifted over time. But the prizes nonetheless still exclude huge tracts of science. Famously, mathematics has never been included. The environmental sciences – oceans and ecology – aren't covered, nor are computing, robotics and artificial intelligence. These exclusions distort the public perception of what sciences are important.**

**Also, the process of awarding the prizes has limitations that clash with the realities of scientific research. It's easy to agree on what scientific advances are important, but it's not so easy to apportion credit. An artist's creations are ephemeral, but generally "individual". If they hadn't created a particular artwork, nobody else would have done so. But in many cases in science, if one researcher didn't make a specific advance, then sooner or later (and usually sooner) another researcher would have.**

## ARCHAEOLOGY - AI reads text from ancient Herculaneum scroll for the first time

A 21-year-old computer-science student has won a global contest to read the first text inside a carbonized scroll from the ancient Roman city of Herculaneum, which had been unreadable since a volcanic eruption in AD 79 — the same one that buried nearby Pompeii. The breakthrough could open up hundreds of texts from the only intact library to survive from Greco-Roman antiquity.

Researchers have used X-ray computerised tomography (CT) scans to delve into the layers of the scroll, but the raw data is inconclusive. It needed an application of AI (artificial intelligence) to analyse and interpret the data, thus highlighting the original written images in the scroll.

Luke Farritor, who is at the University of Nebraska–Lincoln, developed a machine-learning algorithm that has detected Greek letters on several lines of the rolled-up papyrus, including πορφυρας (*porphyras*), meaning 'purple'. Farritor used subtle, small-scale differences in surface texture to train his neural network and highlight the ink. *"When I saw the first image, I was shocked,"* says Federica Nicolardi, a papyrologist at the University of Naples in Italy and a member of the academic committee that reviewed Farritor's findings. *"It was such a dream," she says. Now, "I can actually see something from the inside of a scroll."* Hundreds of scrolls were buried by Mount Vesuvius in October AD 79, when the eruption left Herculaneum under 20 metres of volcanic ash. Early attempts to open the papyri created a mess of fragments, and scholars feared the remainder could never be unrolled or read. *"These are such crazy objects. They're all crumpled and crushed,"* says Nicolardi.

Hopes are that machine learning will open up what are considered to be the "invisible library". This refers to texts that are physically present, but no one can see, including parchment used in medieval book bindings; palimpsests, in which later writing obscures a layer beneath; and cartonnage, in which scraps of old papyrus were used to make ancient Egyptian mummy cases and masks.

https://www.nature.com/articles/d41586-023-03212-1

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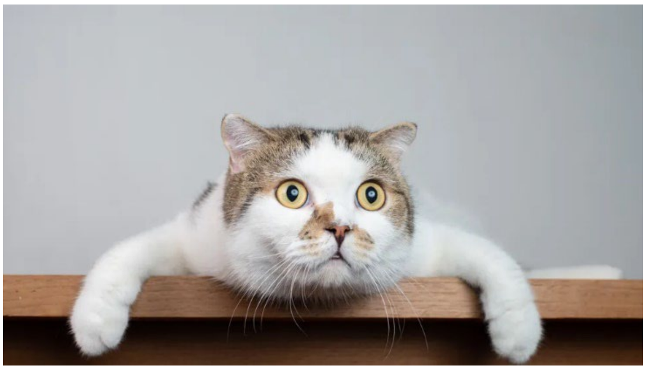
## FELINE SCIENCE - Why cats purr is a surprisingly long-standing mystery

Despite humans living with cats for thousands of years, scientists still don't quite know how or why they make purring sounds. But new research appears to be edging us closer.



Some scientists have long thought that cat purrs are the result of contracting and relaxing muscles in the vocal folds of the larynx. But the new research reveals this may not be the case, and instead suggests cats have special "pads" that help them produce their ultra-low-frequency purrs.

Many animal sounds are made by pushing air through the larynx — or "voice box" — where the air causes the vocal cords to vibrate and make sound. That's how people speak and sing, and how cats make sounds like meows. Some scientists previously thought that cats purr by actively contracting and releasing the muscles in the voice box to create the rhythmic "purring" sound as air is pushed through.

In fact, the new research showed that the cats' organs produced purr-like sounds simply by blowing air through them — without any of the larynx muscles contracting or releasing. What's more, the cats' vocal cords were vibrating similarly to how human vocal cords vibrate while producing the "vocal fry" sound — the stuttering, staccato sound the voice makes when dropping into a lower register. Purring is a very low-frequency sound for a small animal like a cat to make. Just like an upright bass will produce a lower sound than a violin, longer vocal cords will produce a lower sound than shorter vocal cords — that's why mice have squeakier voices than people.

But despite their small size, cats may be able to produce low purring sounds thanks to "pads" of tissue attached to their vocal cords — which may help the cords vibrate at much lower frequencies, the authors of the new study suggested. While this new discovery doesn't completely rule out the theory that cats actively use their muscles to produce a purring sound, it does open the door to new research. Yet reaching a definitive conclusion on how cats purr may be more complicated than it seems.

Theoretically, scientists could put a cat into a functional magnetic resonance imaging (fMRI) machine and watch what happens inside the brain as it purrs. But for that to work, the cat would need to be strapped down to remain completely still inside the scanner, while being convinced to purr at the same time, he added — which would be an ethically problematic experiment to do on an animal. Not just that but, as every cat lover knows, cats only purr when they want to, not when you want them to!

https://www.livescience.com/animals/cats/why-cats-purr-is-a-surprisingly-long-standing-mystery-now-were-one-step-closer-to-solving-it

## FOOD SCIENCE – The Chemistry of Kimchi!

If you think that rotten cabbage would not be your idea of a culinary delight, think again! It may actually be more healthy for you than you can imagine! Well, not "rotten" in the bad sense, but "fermented", which sounds more appetising.

We're talking about *Kimchi*. a traditional Korean dish whose components can vary but usually include some combination of vegetables, garlic, ginger, chili peppers, salt, and fish sauce. The mix is pickled and fermented, which was originally a way to preserve the vegetables for the winter months. Cabbage is the most common vegetable used to make kimchi although carrots, radish, cucumber, and scallions are also frequently used, too. There are hundreds of kimchi recipes that vary depending on the region and season in which they are produced, and it's very easy to make it a vegan dish by keeping all the ingredients plant-based. What makes Kimchi remarkable is the chemistry that goes on in its making.

**Fermentation** is used in the preparation of food for a variety of reasons, such as to produce complex flavours, to protect food from spoiling and to make dough rise. Fermentation refers to the biochemical changes brought about by the action of microorganisms. These can be bacterial or fungal organisms. Bacteria are key agents in the development of the characteristic smell and flavour of certain cheeses. And yeast, a single-celled fungus, is widely used in baking and in the production of ethanol-containing beverages.

The first step in making kimchi is typically to wet the cabbage and coat it with salt. The salt draws out the liquids in the cabbage cells, causing the cabbage to lose its firmness. The liquid is drawn from the cells by **osmosis**. Osmosis is defined as the diffusion of water molecules through a semipermeable membrane, from a place of higher concentration to a place of lower concentration. As the water moves out of the cells, the cell structure collapses, making the cabbage ready for the subsequent steps in the preparation of kimchi.

The salt is then washed off, and a mixture of vegetables, fresh salt, sugar and spices are added. The spices help give the final product its distinct flavour. The next step is where the real action takes place, chemically speaking. The mixture of cabbage and the other ingredients starts to change due to the activity of **microorganisms**. There are dozens, perhaps hundreds, of different kinds of microorganisms in the mix at this phase of the process, all carried in on the different ingredients.

One of the most important organisms for the unique flavours of kimchi is ***Lactobacillus plantarum***, which has the common name lactic acid bacteria. You do not need to add Lactobacillus. There is enough of this organism on the cabbage to carry out the fermentation. Lactobacillus grows best in anaerobic conditions; that is, in low-oxygen conditions. Thus, the kimchi is fermented in a closed container to keep out air. The biological processes carried out by Lactobacillus and other microorganisms in the kimchi result in the formation of lactic acid. As the amount of lactic acid increases, the pH of the kimchi decreases. In other words, the kimchi becomes acidic

https://www.snexplores.org/article/experiment-kimchi-chemistry-fermentation

## WORD OF THE MONTH

# SUPERCOOL (verb, *"SOOP-er-kool"*)

In physics, to supercool a liquid means to chill it below its freezing point without it turning solid.

Supercooling can happen because liquids are loose jumbles of atoms. It's hard for such disordered atoms to lock themselves into the crystal structure of a solid. Liquids often need tiny bits of solid matter to get them started. By latching onto a solid, it becomes easier for the atoms in a liquid to slot into a crystal structure. Bits of dust or other matter can often seed crystal formation in liquids.

If liquids are cooled enough, some of their atoms may spontaneously order themselves into a crystal structure. That tiny bit of solid can then seed more crystal growth. But a liquid can be cooled far below its freezing point before it seeds its own crystal formation. For instance, pure water has avoided turning into ice down to about –46° Celsius (–51° Fahrenheit). That temperature is much lower than water's freezing point of 0 °C (32 °F).

High in Earth's atmosphere, the air is fairly dust-free. Without solid specs to glom onto, water droplets tend to supercool. Such supercooled droplets help form glowing "noctilucent" clouds. Supercooled water is also found in tails behind comets.

Chemicals can help water stay liquid below freezing temperatures. For instance, some fish have anti-freezing proteins. These proteins help prevent the water in their bodies from freezing. This allows the fish to survive at very low temperatures. Similarly, sea water can stay liquid below 0 °C (32° °F) thanks to its salt.