ISASINDIA *Newsletter*

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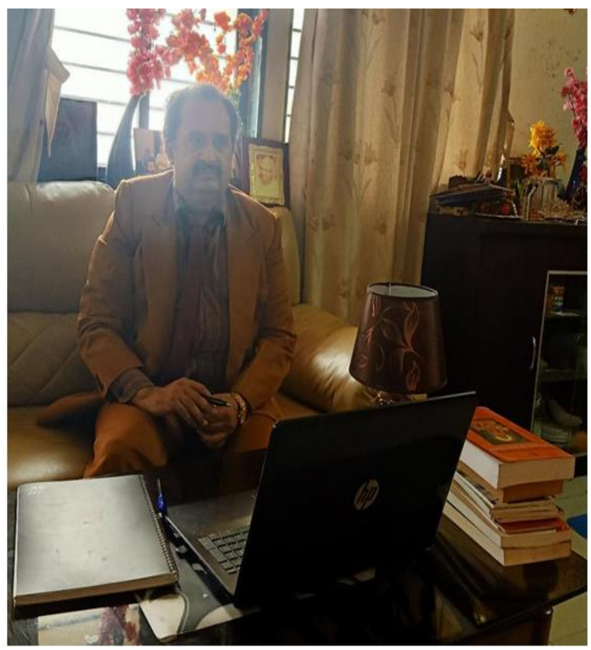
From Editor's Desk

Dear All ISAS Members

This gives me immense pleasure in bringing the 4th issue, the last issue of the year. The soft landing of Chandrayan -3 on lunar surface is matter of utmost pride for our country. India has created history by becoming the first nation in the world to land at south pole of moon and fourth nation to land on moon. Conspicuously, the propulsion module in the lunar mission is powered by nuclear technology, built by Bhabha Atomic Research Centre.



A Miniature Nuclear Gallery has been set up by the NPCIL at Dharwad Regional Science Centre at Karnataka University for people to get acquainted with the progress in the field of nuclear science. Year 2023 Nobel Prize for medicine has been awarded to Katalin Karikó and Drew Weissman who discovered how to deliver mRNA into cells inside the body by enveloping the molecule inside lipid bubbles. The technology was essential for developing some COVID-19 vaccines. The Nobel Prize in chemistry 2023, has been awarded to Moungi G. Bawendi, Louis E. Brus and Aleksey Yekimov for the discovery and development of quantum dots. The Nobel Prize in Physics 2023, has been awarded to Anne L'Huillier, Pierre Agostini and Ferenc Krausz. Nobel laureates have created flashes of light (order of atto second) shorter enough to take snapshots of electrons' extremely rapid movements i.e. able to capture the images of processes occurring inside atoms and molecules. They have opened up the new research field of atto second physics. Updation on various states in which matter exists are discussed in an article. Various states are solid, liquid, gas, supercritical fluid, plasma, Bose-Einstein condensate, degenerate matter and Quark-gluon plasma. Scientists had rare glimpse of 'Nesting Doll' isotope Nitrogen-9 by smashing beams of oxygen isotopes into beryllium atoms in the U.S. National Superconducting Cyclotron Laboratory. The U.K. tech giant Rolls-Royce has proposed a concept of micro-reactor technology capable of powering a future outpost on the moon. The new moon reactor will have a modular design, and many possible uses on earth as well.

Jai Vigyan

Dr. Pradeep Kumar

Chief Editor, ISAS Newsletter

Chandrayaan-3's Untold Success: Nuclear Energy Powers the Propulsion Module Orbiting the Moon

31 October, 2023 | by Paurush Gupta

Source website link: https://www.opindia.com/2023/10/chandrayaan-3-nuclear-energy-powers-the-propulsion-module-orbiting-the-moon/

Conspicuously, the propulsion module in the lunar mission which has been orbiting the Moon is powered by nuclear technology, built by Bhabha Atomic Research Centre, India's premier nuclear research facility.

Another success of Chandrayaan3 revealed, its propulsion module is powered by nuclear energy, RHUs designed and developed by BARC (Image Source - CNBC TV 18)

At around 6:04 PM IST on 23rd August, the Indian Space Research Organisation (ISRO) scripted history by demonstrating soft-landing capabilities on the lunar surface. Evidently, the moment Vikram's lander touched the lunar South Pole, India became the first nation to achieve this momentous feat. Now, almost two months after the momentous success, another untold success related to Chandrayaan-3 has come to the fore. Conspicuously, the propulsion module in the lunar mission which has been orbiting the Moon is powered by nuclear technology, the Times of India reported on 31st October (Tuesday).

Speaking to TOI on Monday (30th October), Atomic Energy Commission chairman Dr. Ajit Kumar Mohanty confirmed this scientific achievement. Dr. Mohanty said that he is happy that India‘s nuclear sector could become a part of such an important space mission.

The propulsion module is equipped with two radioisotope heating units (RHU) that are designed and developed by BARC, ISRO officials were quoted as saying by TOI. This cooperation reportedly makes it the first major joint project of ISRO and BARC. These two RHUs generate one watt and keep the spacecraft at their operational temperatures. Earlier on Sunday (29th October), Chandrayaan 3 project director Peeramuthuvel asserted that ISRO may soon use nuclear resources to maintain instruments in future rovers. However, the ISRO officials emphasised that the RHUs could not be installed on Chandrayaan 3‘s Vikram lander and Pragyan rover because it would have increased their mass. Whereas, the RHUs were installed in the propulsion module for the purpose of experimentation and demonstration. An official said, ―They have been functioning flawlessly. It‘s the first major joint project of ISRO and BARC.

Earlier spacecraft that have used RHUs include NASA‘s Galileo spacecraft to Jupiter, Cassini spacecraft to Saturn, and Voyagers aircrafts 1 and 3. Meanwhile, during the course of its operation, the Vikram lander and Pragyan rover conducted several scientific experiments and confirmed the presence of Sulphur (S) on the lunar surface near the South Pole. ISRO also found traces of various elements that were anticipated to be present on the lunar surface including Aluminium (Al), Calcium (Ca), Iron (Fe), Chromium (Cr), Titanium (Ti), Manganese (Mn), Silicon (Si), and Oxygen (O). Prior to that, ISRO shared some high-quality images of the lunar surface from the navigational camera. The space agency revealed that it successfully navigated a massive 4-metre diameter crater which was located on the earlier path of Pragyan rover. Additionally, ISRO added another historic feat when it shared the first-ever temperature profile of the lunar south pole. Back then, the Space Agency shared that temperature sharply changes at various depths highlighting that the temperature difference could be as high as 10°C in a meagre depth of 2 cm. interestingly, on 4th September, ISRO announced that Vikram Lander exceeded its mission objectives as it successfully performed the hop' experiment. In the experiment, it landed again on the moon's surface after elevating itself by 40 centimetres and travelling to another location nearby.

Now, Miniature Nuclear Gallery Open for Public

09 November, 2023 | by TNN

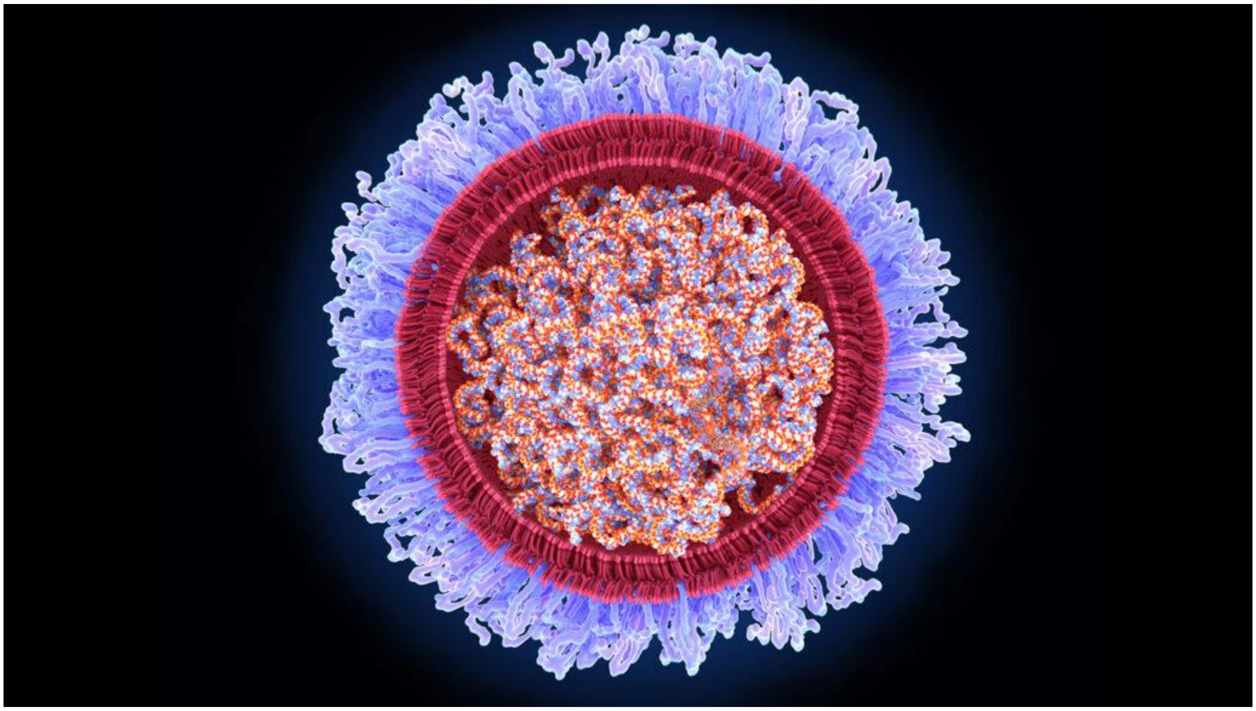
Source website link: https://timesofindia.indiatimes.com/city/hubballi/nuclear-miniature-gallery-opens-today/articleshow/105054789.cms

Karnatak University vice-chancellor KB Gudasi inaugurated the Miniature Nuclear Gallery set by the Nuclear Power Corporation of India Limited (NPCIL), Mumbai at Dharwad Regional Science Centre on Wednesday. Speaking on the occasion he called upon the teachers, students and citizens to visit the gallery to know more about the advances made by India in the field of nuclear science.

Deputy general manager (HR-media), NPCIL Amritesh Shrivatsava said there is a lot of misunderstanding among the people in India about nuclear energy and this needs to be allayed. The potential of atomic energy is high and it does not cause pollution, whereas the thermal energy generated using coal is more pollutant as it emanates carbon dioxide, he said. The newly set up Miniature Nuclear Gallery envisages providing the correct information about nuclear power and its safety and there by helping to generate more nuclear energy and the nation's development, he added. KU registrar Chandrama M, DRSC director VD Bolishetti, Juzoor Bhor of NPCIL and DRSC Curator Sandeep Ranjanagi were present.

Early mRNA research that led to COVID-19 vaccines wins 2023 medicine Nobel Prize

Biochemists Katalin Karikó and Drew Weissman overcame hurdles that enabled vaccine development



JUAN GAERTNER/SCIENCE PHOTO LIBRARY/GETTY IMAGES

By Tina Hesman Saey, Meghan Rosen and Erin Garcia de Jesús

Researchers Katalin Karikó and Drew Weissman discovered how to deliver mRNA into cells inside the body by enveloping the molecule inside lipid bubbles (illustrated). Technology that was essential for developing some COVID-19 vaccines earned the pair the 2023 Nobel Prize in physiology or medicine.

Two scientists who laid the groundwork for what would become among the most influential vaccines of all time have been awarded the 2023 Nobel Prize in medicine or physiology. Biochemist Katalin Karikó, now at the University of Szeged in Hungary, and Drew Weissman of the University of Pennsylvania were honored for their research on modifications of mRNA that made the first vaccines against COVID-19 possible (SN: 12/15/21).

“Everybody has experienced the COVID-19 pandemic that affects our life, economy and public health. It was a traumatic event,” said Qiang Pan-Hammarström, a member of the Nobel Assembly at the Karolinska Institute in Stockholm, which awards the medicine or physiology prize. Her remarks came on October 2 after a news briefing to announce the winners. “You probably don’t need to emphasize more that the basic discovery made by the laureates has made a huge impact on our society.”

As of September 2023, more than 13.5 billion COVID-19 vaccine doses — including mRNA vaccines as well as other kinds of shots — had been administered since they first became available in December 2020, according to the World Health Organization. In the year after their introduction, the shots are estimated to have saved nearly 20 million lives globally. In the United States, where mRNA COVID-19 shots made by Moderna and Pfizer/BioNTech accounted for the vast majority of vaccinations, the vaccines are estimated to have prevented 1.1 million additional deaths and 10.3 million hospitalizations. A different kind of vaccine RNA is DNA’s lesser-known chemical cousin. Cells make RNA copies of genetic instructions contained in DNA. Some of those RNA copies, known as messenger RNA, or mRNA, are used to build proteins. Messenger RNA “literally tells your cells what proteins to make,” says Kizzmekia Corbett-Helaire, a viral immunologist at the Harvard T. H. Chan School of Public Health in Boston. Proteins do much of the important work that keeps cells, and the organisms they’re a part of, alive and well. The mRNA vaccines work a bit differently than traditional immunizations. Most traditional vaccines use viruses or bacteria — either weakened or killed — or proteins from those pathogens to provoke the immune system into making protective antibodies and other defenses against future infections. The COVID-19 vaccines made by Pfizer/BioNTech and Moderna instead contain mRNA that carries instructions for making one of the coronavirus's proteins (SN: 2/21/20). When a person gets an mRNA shot, the genetic material gets into their cells and triggers the cells to produce the viral protein for a short amount of time. When the immune system sees the viral protein, it builds defenses to prevent serious illness if the person later gets infected with the coronavirus.

Vaccines using mRNA were a good choice to combat the pandemic, Corbett-Helaire says. The technology allows scientists to "skip that step of making large amounts of proteins in the laboratory and instead … tell the body to do things that the body already does, except now we make an extra protein," she says.

In addition to protecting people from the coronavirus, mRNA vaccines may also work against other infectious diseases and cancer. Scientists might also use the technology to help people with certain rare genetic diseases make enzymes or other proteins they lack. Clinical trials are under way for many of these uses, but it could take years before scientists know the results (SN: 12/17/21).

Decades of work from Katalin Karikó (left) and Drew Weissman (right) made possible COVID-19 vaccines from Pfizer/BioNTech and Moderna.Peggy Peterson, University of Pennsylvania

The first mRNA vaccine for COVID-19 became available just under a year into the pandemic, but the technology behind it has been decades in the making. In 1997, Karikó and Weissman met at the copy machine, Karikó said during a news conference October 2 at the University of Pennsylvania. She told him about her work with RNA, and he shared his interest in vaccines. Although housed in separate buildings, the researchers worked together to solve one fundamental problem that could have derailed mRNA vaccines and therapies: Pumping regular mRNA into the body gets the immune system riled up in bad ways, producing a flood of immune chemicals called cytokines. Those chemicals can trigger damaging inflammation. And this unmodified mRNA produces very little protein in the body. The researchers found that swapping the RNA building block uridine for modified versions, first pseudouridine and then N1-methylpseudouridine, could dampen the bad immune reaction. That nifty chemistry, first reported in 2005, allowed researchers to rein in the immune response and safely deliver the mRNA to cells.“The messenger RNA has to hide and it has to go unnoticed by our bodies, which are very brilliant at destroying things that are foreign,” Corbett-Helaire says. “The modifications that [Karikó and Weissman] worked on for a number of years really were fundamental to allowing the mRNA therapeutics to hide while also being very helpful to the body.”

In addition, the modified mRNA produced lots of protein that could spark an immune response, the team showed in 2008 and 2010. It was this work on modifying mRNA building blocks that the prize honors.For years, “we couldn’t get people to notice RNA as something interesting,” Weissman said at the Penn news conference. Vaccines using the technology failed clinical trials in the early 1990s, and most researchers gave up. But Karikó “lit the match,” and they spent the next 20 years figuring out how to get it to work, Weissman said. “We would sit together in 1997 and afterwards and talk about all the things that we thought RNA could do, all of the vaccines and therapeutics and gene therapies, and just realizing how important it had the potential to be. That’s why we never gave up.”

In 2006, Karikó and Weissman started a company called RNARx to develop mRNA-based treatments and vaccines. After Karikó joined the German company BioNTech in 2013, she and Weissman continued to collaborate. They and colleagues reported in 2015 that encasing mRNA in bubbles of lipids could help the fragile RNA get into cells without getting broken down in the body. The researchers were developing a Zika vaccine when the pandemic hit, and quickly applied what they had learned toward containing the coronavirus. The duo’s work was not always so celebrated. Thomas Perlmann, Secretary General of the Nobel Assembly at the Karolinska Institute, asked the newly minted laureates whether they were surprised to have won. He said that Karikó was overwhelmed, noting that just 10 years ago she was terminated from her job and had to move to Germany without her family to get another position. She never won a grant from the U.S. National Institutes of Health to support her work. “She struggled and didn’t get recognition for the importance of her vision,” Perlmann said, but she had a passion for using mRNA therapeutically. “She resisted the temptation to sort of go away from that path and do something maybe easier.” Karikó is the 61st woman to win a Nobel Prize since 1901, and the 13th to be awarded a prize in physiology and medicine. Though it often takes decades before the Nobel committees recognize a discovery, sometimes recognition comes relatively swiftly. For instance, Emmanuelle Charpentier and Jennifer Doudna won the Nobel Prize for chemistry in 2020 a mere eight years after the researchers published a description of the genetic scissors CRISPR/Cas 9 (SN: 10/7/20).

“I never expected in my entire life to get the Nobel Prize,” Weissman said, especially not a mere three years after the vaccines demonstrated their medical importance. Perlmann told him the Nobel committee was seeking to be “more current” with its awards, he said. The timely Nobel highlights that “there are just a million other possibilities for messenger RNA therapeutics … beyond the vaccines,” Corbett-Helaire says. The researchers said at the Penn news conference that they weren’t sure the early morning phone call from Perlmann was real. On the advice of Weissman’s daughter, they waited for the Nobel announcement. “We sat in bed. [I was] looking at my wife, and my cat is begging for food,” he said. “We wait, and the press conference starts, and it was real. So that’s when we really became excited.” Karikó and Weissman will share the prize of 11 million Swedish kronor, or roughly $1 million.

The Nobel Prize in Chemistry 2023, the discovery and development of quantum dots

Moungi G. Bawendi, Louis E. Brus and Aleksey Yekimov are awarded the Nobel Prize in Chemistry 2023 for the discovery and development of quantum dots. These tiny particles have unique properties and now spread their light from television screens and LED lamps. They catalyse chemical reactions and their clear light can illuminate tumour tissue for a surgeon.

The Royal Swedish Academy of Sciences has decided to award the Nobel Prize in Chemistry 2023 to

ALEKSEY YEKIMOV

Born 1945 in the former USSR. PhD 1974 from Ioffe Physical-Technical Institute, Saint Petersburg, Russia. Formerly Chief Scientist at Nanocrystals Technology Inc., New York, NY, USA.

LOUIS E. BRUS

Born 1943 in Cleveland, OH, USA. PhD 1969 from Columbia University, New York, NY, USA. Professor at Columbia University, New York, NY, USA.

MOUNGI G. BAWENDI

Born 1961 in Paris, France. PhD 1988 from University of Chicago, IL, USA. Professor at Massachusetts Institute of Technology (MIT), Cambridge, MA, USA.

They added colour to nanotechnology

"Toto, I've a feeling we're not in Kansas anymore," is a classic quote from the film The Wizard of Oz. Twelve-year-old Dorothy faints onto her bed when her house is swept away by a powerful tornado, but when the house lands again and she steps outside the door, her dog Toto in her arms, everything has changed. Suddenly she is in a magical, technicolour world. If an enchanted tornado were to sweep into our lives and shrink everything to nano dimensions, we would almost certainly be as astonished as Dorothy in the land of Oz. Our surroundings would be dazzlingly colourful and everything would change. Our gold earrings would suddenly glimmer in blue, while the gold ring on our finger would shine a ruby red. If we tried to fry something on the gas hob, the frying pan might melt. And our white walls – whose paint contains titanium dioxide – would start generating lots of reactive oxygen species.

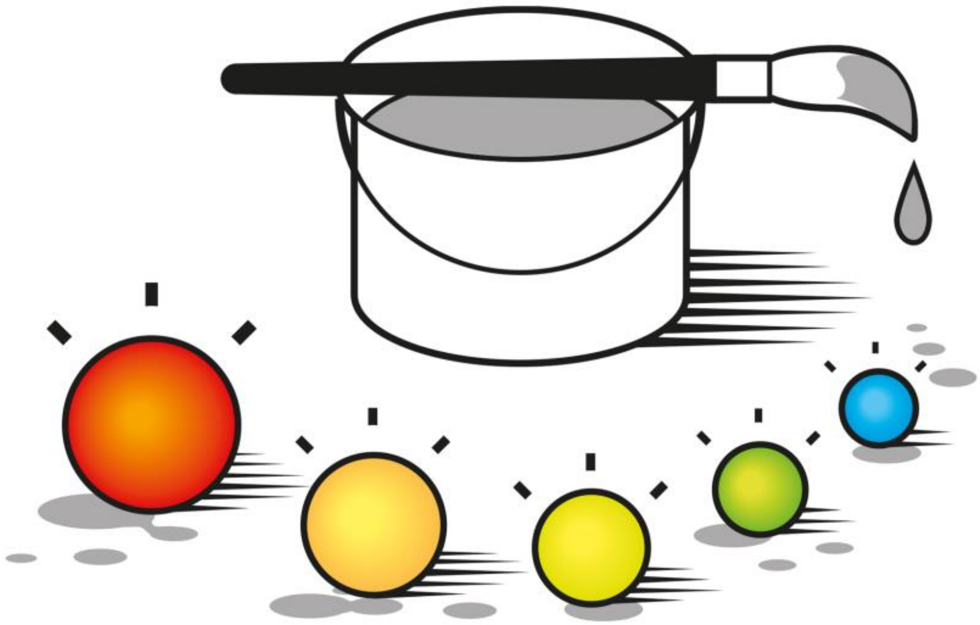


Figure 1. Quantum dots have given us new opportunities for creating coloured light. © Johan Jarnestad/The Royal Swedish Academy of Sciences

Size matters on the nanoscale

In the nanoworld, things really do behave differently. Once the size of matter starts to be measured in millionths of a millimetre, strange phenomena start to occur – quantum effects – that challenge our intuition. The 2023 Nobel Laureates in Chemistry have all been pioneers in the exploration of the nanoworld. In the early 1980s, Louis Brus and Aleksey Yekimov succeeded in creating – independently of each other – quantum dots, which are nanoparticles so tiny that quantum effects determine their characteristics. In 1993, Moungi Bawendi revolutionised the methods for manufacturing quantum dots, making their quality extremely high – a vital prerequisite for their use in today's nanotechnology. Thanks to the work of the laureates, humanity is now able to utilise some of the peculiar properties of the nanoworld. Quantum dots are now found in commercial products and used across many scientific disciplines, from physics and chemistry to medicine – but we are getting ahead of ourselves. Let's uncover the background to the Nobel Prize in Chemistry 2023.

Figure 2. 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. © Johan Jarnestad/The Royal Swedish Academy of Sciences

For decades, quantum phenomena in the nanoworld were just a prediction

When Aleksey Yekimov and Louis Brus produced the first quantum dots, scientists already knew that they could – in theory – have unusual characteristics. In 1937, the physicist Herbert Fröhlich had already predicted that nanoparticles would not behave like other particles. He explored the theoretical consequences of the famous Schrödinger equation, which shows that when particles become extremely small there is less space for the material's electrons. In turn, the electrons – which are both waves and particles – are squeezed together. Fröhlich realised that this would result in drastic changes to the material's properties. Researchers were fascinated by this insight and, using mathematical tools, they succeeded in predicting numerous size-dependent quantum effects. They also worked to try to demonstrate them in reality, but this was easier said than done because they needed to sculpt a structure that was about a million times smaller than a pinhead.

Few people thought quantum effects could be utilised

Still, in the 1970s, researchers did succeed in making such a nanostructure. Using a type of molecular beam, they created a nano-thin layer of coating material on top of a bulk material. Once the assembly was complete, they were able to show that the coating's optical properties varied depending on how thin it was, an observation that matched the predictions of quantum mechanics. This was a major breakthrough, but the experiment required very advanced technology. Researchers needed both an ultra-high vacuum and temperatures close to absolute zero, so few people expected that quantum mechanical phenomena would be put to practical use. However, now and again science offers up the unexpected and, this time, the turning point was due to studies of an ancient invention: coloured glass.

A single substance can give glass different colours

The oldest archaeological finds of coloured glass are from several thousand years ago. Glassmakers have tested their way to an understanding of how glass can be produced in all the colours of the rainbow. They added substances such as silver, gold and cadmium and then played with different temperatures to produce beautiful shades of glass. In the nineteenth and twentieth centuries, when physicists started to investigate the optical properties of light, the glassmakers' knowledge was put to use. Physicists could use coloured glass to filter out selected wavelengths of light. To optimise their experiments, they started to produce glass themselves, which led to important insights. One thing they learned was that a single substance could result in completely differently coloured glass. For example, a mixture of cadmium selenide and cadmium sulphide could make glass turn either yellow or red – which one it became depended on how much the molten glass was heated and how it was cooled. Eventually, they were also able to show that the colours came from particles forming inside the glass and that the colour depended on the particles' size. This was more or less the state of the knowledge at the end of the 1970s, when one of this year's laureates, Aleksey Yekimov, a recent doctoral graduate, started working at the S. I. Vavilov State Optical Institute in what was then the Soviet Union.

Aleksey Yekimov maps the mysteries of coloured glass

The fact that a single substance could result in different coloured glass interested Aleksey Yekimov, because it is actually illogical. If you paint a picture in cadmium red, it will always be cadmium red, unless you mix in other pigments. So how could a single substance give glass of different colours? During his doctoral degree, Yekimov studied semiconductors – important components in microelectronics. In this field, optical methods are used as diagnostic tools for assessing the quality of semiconducting material. Researchers shine light on the material and measure the absorbance. This reveals what substances the material is made from and how well-ordered the crystal structure is. Yekimov was familiar with these methods, so he began using them to examine coloured glass. After some initial experiments, he decided to systematically produce glass that was tinted with copper chloride. He heated the molten glass to a range of temperatures between 500°C and 700°C, varying the heating time from 1 hour to 96 hours. Once the glass had cooled and hardened, he X-rayed it. The scattered rays showed that tiny crystals of copper chloride had formed inside the glass and the manufacturing process affected the size of these particles. In some of the glass samples they were only about two nanometres, in others they were up to 30 nanometres. Interestingly, it turned out that the glass' light absorption was affected by the size of the

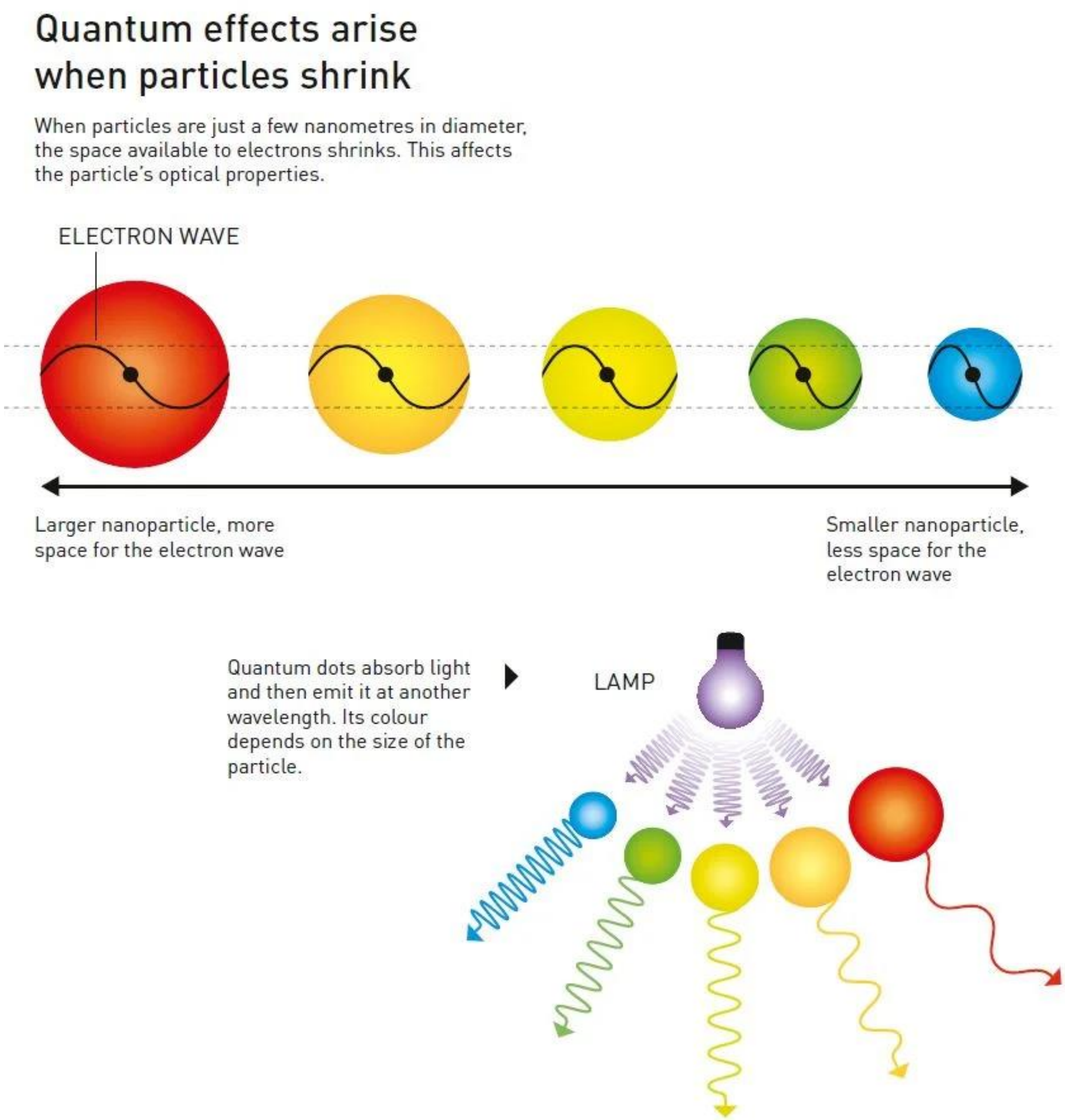


Figure 3. Quantum effects arise when particles shrink. © Johan Jarnestad/The Royal Swedish Academy of Sciences

particles. The biggest particles absorbed the light in the same way that copper chloride normally does, but the smaller the particles, the bluer the light that they absorbed. As a physicist, Yekimov was well acquainted with the laws of quantum mechanics and quickly realised that he had observed a size-dependent quantum effect (figure 3).

This was the first time someone had succeeded in deliberately producing quantum dots – nanoparticles that cause size-dependent quantum effects. In 1981, Yekimov published his discovery in a Soviet scientific journal, but this was difficult for researchers on the other side of the Iron Curtain to access. Therefore, this year's next Nobel Prize Laureate in Chemistry – Louis Brus – was unaware of Aleksey Yekimov's discovery when, in 1983, he was the first researcher in the world to discover size-dependent quantum effects in particles floating freely in a solution.

Brus shows that the strange properties of particles are quantum effects

Louis Brus was working at Bell Laboratories in the US, with the long-term aim of making chemical reactions happen using solar energy. To achieve this, he was using particles of cadmium sulphide, which can capture light and then utilise its energy to drive reactions. The particles were in a solution and Brus made them very small, because this gave him a larger area on which the chemical reactions could take place; the more a material is chopped up, the greater the surface area it will expose to its surroundings. During his work with these tiny particles, Brus noticed something strange – their optical properties changed after he had left them on the lab bench for a while. He guessed that this could be because the particles had grown, so to confirm his suspicions he produced cadmium sulphide particles that were just about 4.5 nanometres in diameter. Brus then compared the optical properties of these newly made particles with those of the larger particles, which had a diameter of about 12.5 nanometres. The larger particles absorbed light at the same wavelengths as cadmium sulphide generally does, but the smaller particles had an absorption that shifted towards blue (figure 3).

Just like Yekimov, Brus understood that he had observed a size-dependent quantum effect. He published his discovery in 1983 and then started investigating particles made from a range of other substances. The pattern was the same – the smaller the particles, the bluer the light they absorbed.

The periodic table gained a third dimension

This is where you may be tempted to ask "Why does it matter if a substance's absorbance is slightly more towards blue? Why is that so amazing?"

Well, the optical changes revealed that the substance's characteristics had completely changed. A substance's optical properties are governed by its electrons. The same electrons also govern the substance's other properties, such as its ability to catalyse chemical reactions or conduct electricity. So when researchers detected the changed absorption they understood that, in principle, they were looking at an entirely new material.

If you want to understand the magnitude of this discovery, you can imagine that the periodic table suddenly gained a third dimension. An element's properties are not only affected by the number of electron shells and how many electrons there are it the outer shell but, at the nano level, size also matters. A chemist who wanted to develop a new material thus had another factor to play with – of course this tickled researchers' imaginations!

There was just one problem. The methods Brus had used to fabricate nonparticles generally resulted in unpredictable quality. Quantum dots are tiny crystals (figure 2) and the ones that could be produced at that time often contained defects. They were also of varying sizes. It was possible to control how the crystals were formed so the particles had a given average size, but if researchers wanted all the particles in a solution to be about the same size they had to sort them after they were made. This was a difficult process that hindered development.

Moungi Bawendi revolutionises the production of quantum dots

This was a problem that this year's third Nobel Prize Laureate in Chemistry decided to solve. Moungi Bawendi started his postdoctoral training at Louis Brus' laboratory in 1988, where intensive work was underway to improve the methods used to produce quantum dots. Using a range of solvents, temperatures and techniques, they experimented with a variety of substances to try and form well-organised nanocrystals. And the crystals were getting better, but were still not good enough.

However, Bawendi did not give up. When he started working as a research leader at the Massachusetts Institute of Technology, MIT, he continued his efforts to produce higher quality nanoparticles. The major breakthrough came in 1993, when the research group injected the substances that would form nanocrystals into a heated and carefully chosen solvent. They injected as much of the substances as was necessary to precisely saturate the solution, which led to tiny crystal embryos beginning to form simultaneously (figure 4).

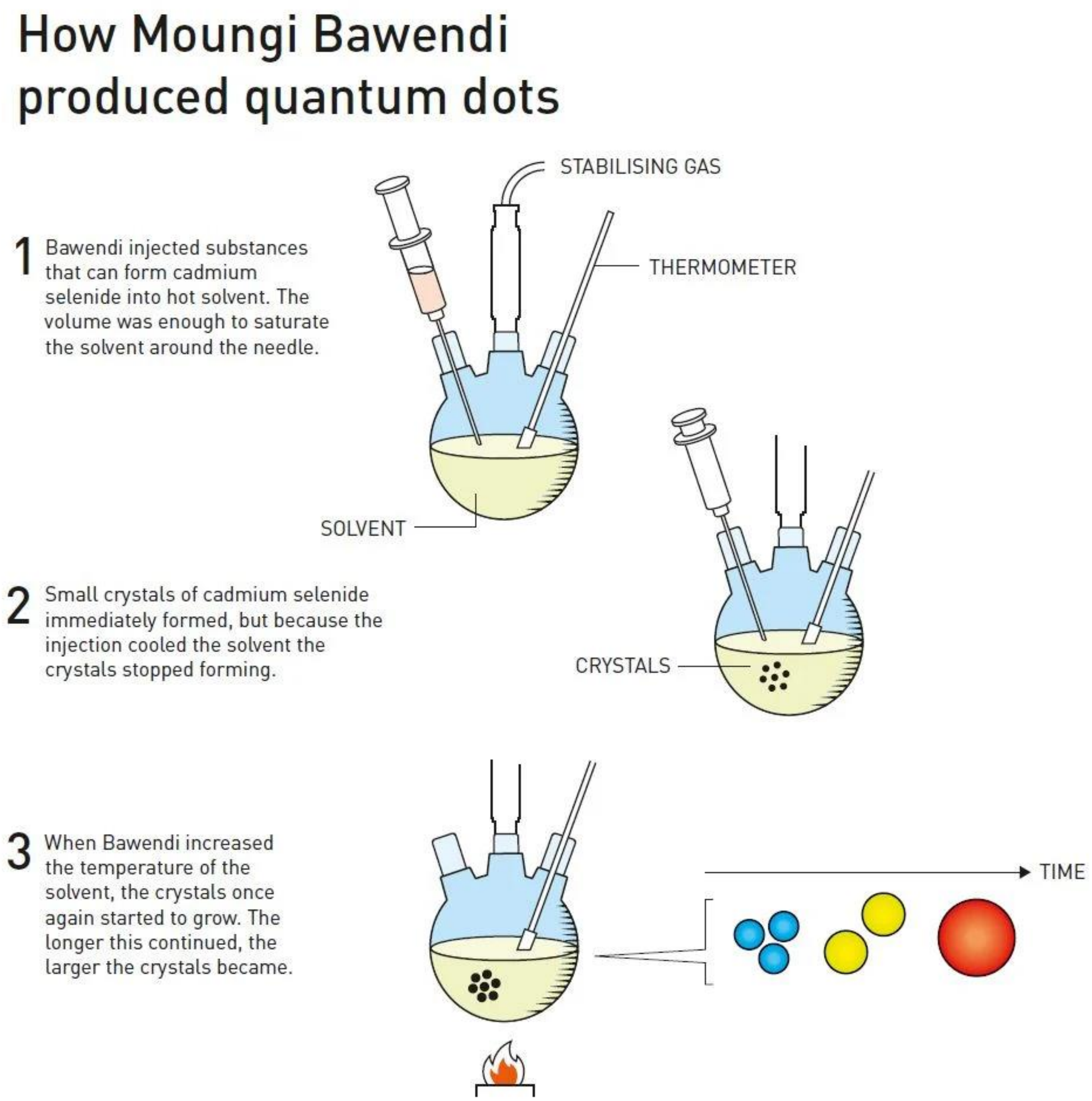


Figure-4:How Moungi Bawendi produced quantom dots. © Johan Jarnestad/The Royal Swedish Academy of Sciences

Then, by dynamically varying the temperature of the solution, Moungi Bawendi and his research group succeeded in growing nanocrystals of a specific size. During this phase, the solvent helped give the crystals a smooth and even surface.

The nanocrystals that Bawendi produced were almost perfect, giving rise to distinct quantum effects. Because the production method was easy to use, it was revolutionary – more and more chemists started working with nanotechnology and began to investigate the unique properties of quantum dots.

The luminous properties of quantum dots find commercial uses

Thirty years later, quantum dots are now an important part of nanotechnology's toolbox and are found in commercial products. Researchers have primarily utilised quantum dots to create coloured light. If quantum dots are illuminated with blue light, they absorb the light and emit a different colour. Modifying the size of the particles makes it possible to determine exactly what colour they should glow (figure 3).

The luminous properties of quantum dots are utilised in computer and television screens based on QLED technology, where the Q stands for quantum dot. In these screens, blue light is generated using the energy-efficient diodes that were recognised with the Nobel Prize in Physics 2014. Quantum dots are used to change the colour of some of the blue light, transforming it into red or green. This makes it possible to produce the three primary colours of light needed in a television screen.

Similarly, quantum dots are used in some LED lamps to adjust the cold light of the diodes. The light can then become as energising as daylight or as calming as the warm glow from a dimmed bulb. The light from quantum dots can also be used in biochemistry and medicine. Biochemists attach quantum dots to biomolecules to map cells and organs. Doctors have begun investigating the potential use of quantum dots to track tumour tissue in the body. Chemists instead use the catalytic properties of quantum dots to drive chemical reactions.

Further reading

Additional information on this year's prizes, including a scientific background in English, is available on the website of the Royal Swedish Academy of Sciences, www.kva.se, and at www.nobelprize.org, where you can watch video from the press conferences, the Nobel Lectures and more. Information on exhibitions and activities related to the Nobel Prizes and the Prize in Economic Sciences is available at www.nobelprizemuseum.se.

Quantum dots are thus bringing the greatest benefit to humankind, and we have just begun to explore their potential. Researchers believe that in the future quantum dots can contribute to flexible electronics, miniscule sensors, slimmer solar cells and perhaps encrypted quantum communication. One thing is certain – there is a lot left to learn about amazing quantum phenomena. So if there’s a 12-year-old Dorothy out there looking for adventure, the nanoworld has a great deal to offer.

Radiation Treatment Could be Used to Treat Heart Failure: Study

Source website link: https://theprint.in/health/radiation-treatment-could-be-used-to-treat-heart-failure-study/1869647/

Cardiologists and radiation oncologists at Washington University School of Medicine in St Louis pioneered the use of radiation therapy, a cancer-fighting technique, to treat patients with ventricular tachycardia, a potentially fatal abnormal heartbeat. The research team discovered that low-dose radiation therapy appears to enhance heart function in various forms of heart failure after analysing the cardiac effects of radiation in a small number of these individuals and modeling the effects of low-dose radiation in mice with heart failure.

Representative Image

More research is needed before the researchers can test this therapy in heart failure patients, but the study implies that the effects of radiation on wounded hearts with high levels of inflammation may be more variable and maybe helpful than previously recognised. According to the study, which was published in the journal Med, low-dose radiation therapy improves cardiac function, at least in part, by reducing the amount of inflammatory immune cells in the heart muscle. The

radiation therapy used to treat ventricular tachycardia is targeted to a specific location in the heart;however, a large portion of the rest of the heart gets a low-doseexposure, said co-senior author and cardiologist Ali Javaheri, MD,
PhD, an assistant professor of medicine.

We wanted to understand the effects of that low-dose radiation on these patients‘ hearts. There was concern that it could be harmful to overall heart function, even though it treats dangerous arrhythmia. We were surprised to find the opposite: Heart function appeared to be improved after radiation therapy, at least in the short term. About 6.2 million American adults currently live with heart failure, according to the Centers for Disease Control and Prevention. More than half of heart failure patients hospitalised for the condition die within five years of that first hospitalisation, demonstrating a need for better therapies. A failing heart gradually loses its ability to properly supply the body with oxygenated blood. A complex condition, heart failure can have diverse triggers, including a past heart attack, viral infection or chronic arrhythmias such as ventricular tachycardia. A group of nine patients with ventricular tachycardia was evaluated with a cardiac MRI before and after radiation treatment, with the MRIs showing improved heart function
soon after radiation.

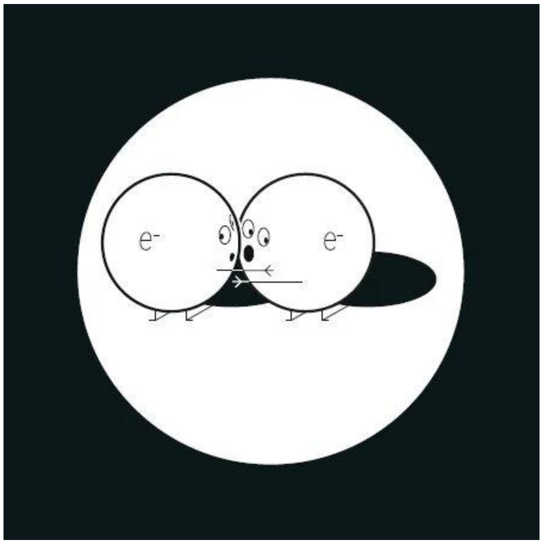
In particular, the patients‘ hearts showed improved pumping capacity of the left ventricle, which supplies blood to the entire body. The improvement was seen a few days after treatment, so it was deemed unlikely to be due to the reduction of the arrhythmia, which happens more gradually over the ensuing weeks and months. The researchers also studied the effects of similar low-dose radiation on the heart in groups of mice with heart failure from three different causes. Similar to what was observed in human patients, the researchers found improved heart function in mice receiving radiation therapy, especially in the left ventricle. In mice with progressive heart failure, radiation therapy increased the survival of the animals, indicating that improvements in heart function translated to improved survival. The researchers found that the failing mouse hearts that received radiation had reduced fibrosis or scar tissue and reductions in cardiac macrophages, a type of immune cell that can drive inflammation in the heart. In general, the irradiated hearts had fewer cells that proliferate quickly such as immune cells and fibroblasts which tend to contribute to worsening heart failure. In contrast, normal heart muscle cells generally do not divide often, if at all.

We know that rapidly dividing cells , such as cancer cells, for example tend to be more susceptible to death by radiation, said co-senior author and radiation oncologist Carmen Bergom, MD, PhD, an associate professor of radiation oncology. The effect we see in these hearts is likely more complex than a simple reduction of rapidly dividing inflammatory immune cells. We are continuing our research to delve more deeply into what else may be happening, but we have been pleasantly surprised to see evidence that low-dose radiation in these hearts may reduce inflammation and help remodel the heart in a beneficial way (ANI)

The Nobel Prize in Physics 2023

Through their experiments, this year's laureates have created flashes of light that are short enough to take snapshots of electrons' extremely rapid movements. Anne L'Huillier discovered a new effect from laser light's interaction with atoms in a gas. Pierre Agostini and Ferenc Krausz demonstrated that this effect can be used to create shorter pulses of light than were previously possible.

Electrons in pulses of light



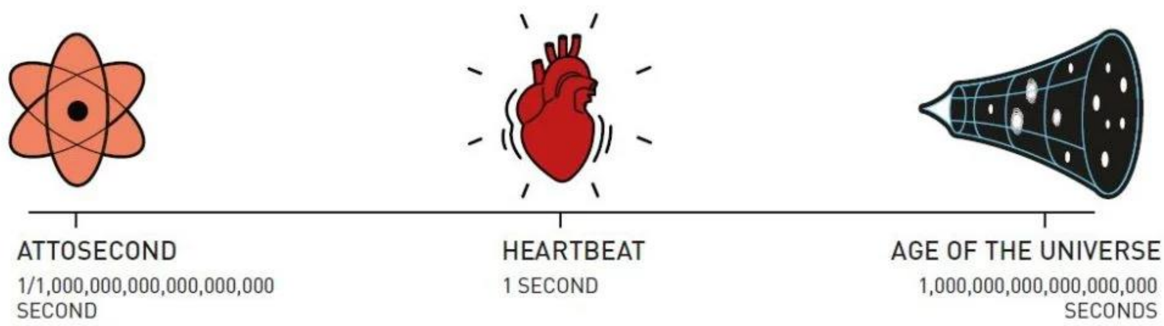
A tiny hummingbird can beat its wings 80 times per second. We are only able to perceive this as a whirring sound and blurred movement. For the human senses, rapid movements blur together, and extremely short events are impossible to observe. We need to use technological tricks to capture or depict these very brief instants.

High-speed photography and strobe lighting make it possible to capture detailed images of fleeting phenomena. A highly focused photograph of a hummingbird in flight requires an exposure time that is much shorter than a single wingbeat. The faster the event, the faster the picture needs to be taken if it is to capture the instant. The same principle applies to all the methods used to measure or depict rapid processes; any measurement must be done more quickly than the time it takes for the system being studied to undergo a noticeable change, otherwise the result is vague. This year's laureates have conducted experiments that demonstrate a method for producing pulses of light that are brief enough to capture images of processes inside atoms and molecules.

Atoms' natural time scale is incredibly short. In a molecule, atoms can move and turn in millionths of a billionth of a second, femtoseconds. These movements can be studied with the very shortest pulses that can be produced with a laser – but when entire atoms move the timescale is determined by their large and heavy nuclei, which are extremely slow compared to light and nimble electrons. When electrons move inside atoms or molecules, they do it so quickly that changes are blurred out in a femtosecond. In the world of electrons, positions and energies change at speeds of between one and a few hundred attoseconds, where an attosecond is one billionth of a billionth of a second.

An attosecond is so short that that the number of them in one second is the same as the number of seconds that have elapsed since the universe came into existence, 13.8 billion years ago. On a more relatable scale, we can imagine a flash of light being sent from one end of a room to the opposite wall – this takes ten billion attoseconds.

A femtosecond was long regarded as the limit for the flashes of light it was possible to produce. Improving existing technology was not enough to see processes occurring on the amazingly brief timescales of electrons; something entirely new was required. This year's laureates conducted experiments that opened up the new research field of attosecond physics.

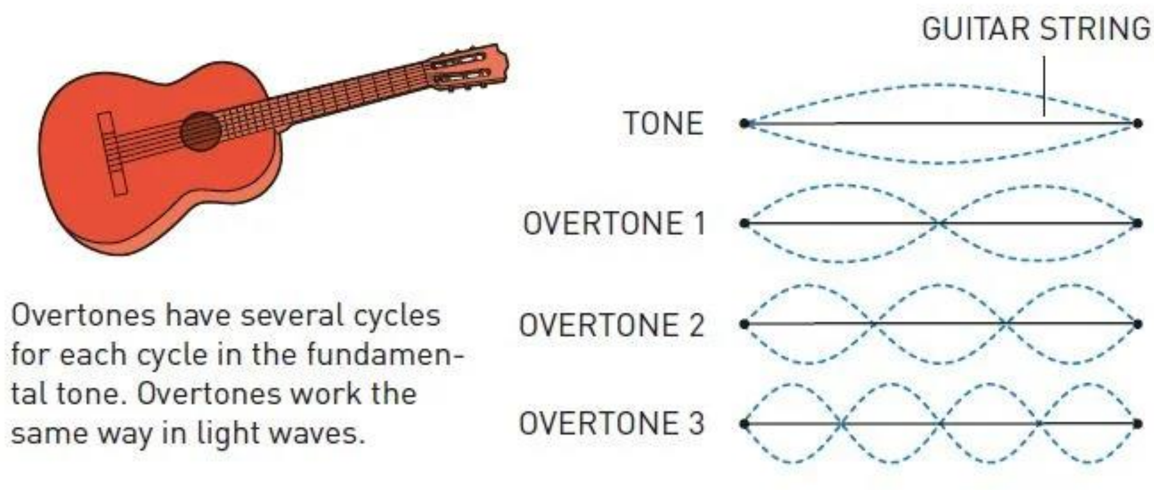


Electrons' movements in atoms and molecules are so rapid that they are measured in attoseconds. An attosecond is to one second as one second is to the age of the universe. © Johan Jarnestad/The Royal Swedish Academy of Sciences

Shorter pulses with the help of high overtones

Light consists of waves – vibrations in electrical and magnetic fields – that move through a vacuum faster than anything else. These have different wavelengths, equivalent to different colours. For example, red light has a wavelength of about 700 nanometres, one hundredth the width of a hair, and it cycles at about four hundred and thirty thousand billion times per second. We can think of the shortest possible pulse of light as the length of a single period in the light wave, the cycle where it swings up to a peak, down to a trough, and back to its starting point. In this case, the wavelengths used in ordinary laser systems are never able to get below a femtosecond, so in the 1980s this was regarded as a hard limit for the shortest possible bursts of light.

The mathematics that describes waves demonstrates that any wave form can be built if enough waves of the right sizes, wavelengths and amplitudes (distances between peaks and troughs) are used. The trick to attosecond pulses is that it is possible to make shorter pulses by combining more and shorter wavelengths. Observing electrons' movements on an atomic scale requires short-enough pulses of light, which means combining short waves of many different wavelengths. To add new wavelengths to light, more than just a laser is necessary; the key to accessing the briefest instant ever studied is a phenomenon that arises when laser light passes through a gas. The light interacts with its atoms and causes overtones – waves that complete a number of entire cycles for each cycle in the original wave. We can compare this to the overtones that give a sound its particular character, allowing us to hear the difference between the same note played on a guitar and a piano.



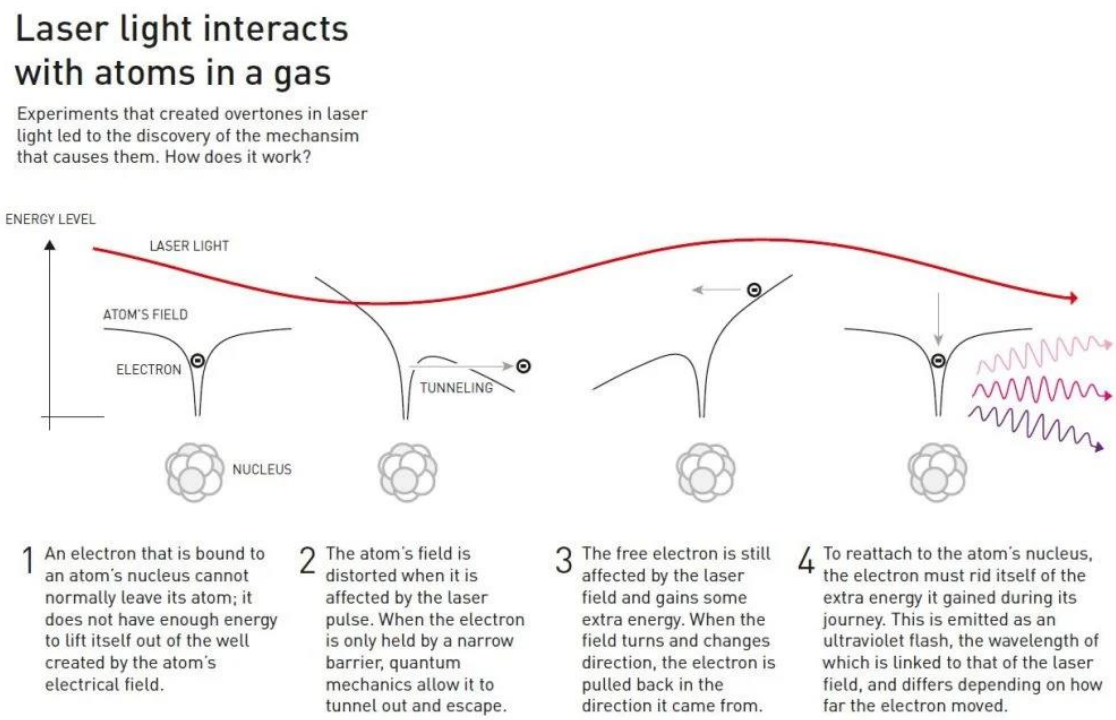
Overtones have several cycles for each cycle in the fundamental tone. Overtones work the same way in light waves. © Johan Jarnestad/The Royal Swedish Academy of Sciences.

In 1987, Anne L'Huillier and her colleagues at a French laboratory were able to produce and demonstrate overtones using an infrared laser beam that was transmitted through a noble gas. The infrared light caused more and stronger overtones than the laser with shorter wavelengths that had been used in previous experiments. In this experiment, many overtones of about the same light intensity were observed.

In a series of articles, L'Huillier continued to explore this effect during the 1990s, including at her new base, Lund University. Her results contributed to the theoretical understanding of this phenomenon, laying the foundation of the next experimental breakthrough.

Escaping electrons create overtones

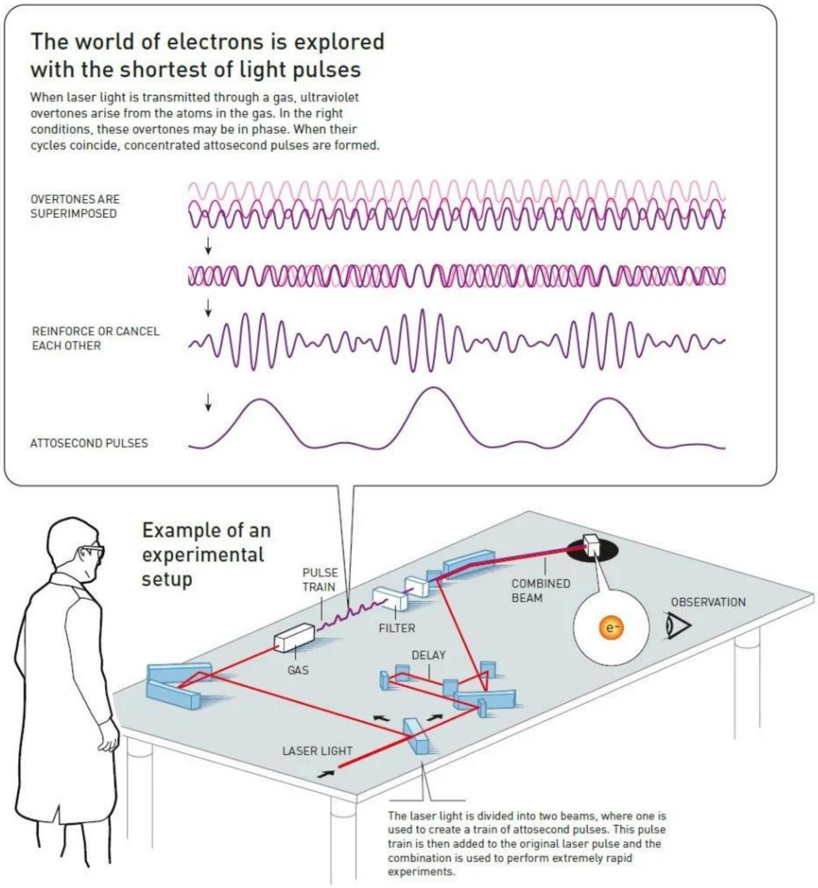
When the laser light enters the gas and affects its atoms, it causes electromagnetic vibrations that distort the electric field holding the electrons around the atomic nucleus. The electrons can then escape from the atoms. However, the light's electrical field vibrates continuously and, when it changes direction, a loose electron may rush back to its atom's nucleus. During the electron's excursion it collected lots of extra energy from the laser light's electrical field and, to reattach to the nucleus, it must release its excess energy as a pulse of light. These light pulses from the electrons are what create the overtones that appear in the experiments.



Laser light interacts with atoms in a gas. © Johan Jarnestad/The Royal Swedish Academy of Sciences

Light's energy is associated with its wavelength. The energy in the emitted overtones is equivalent to ultraviolet light, which has shorter wavelengths than the light visible to the human eye. Because the energy comes from the laser light's vibrations, the overtones' vibration will be elegantly proportional to the wavelength of the original laser pulse. The result of the light's interaction with many different atoms is different light waves with a set of specific wavelengths.

Once these overtones exist, they interact with each other. The light becomes more intense when the lightwaves' peaks coincide, but becomes less intense when the peak in one cycle coincides with the trough of another. In the right circumstances, the overtones coincide so that a series of pulses of ultraviolet light occur, where each pulse is a few hundred attoseconds long. Physicists understood the theory behind this in the 1990s, but the breakthrough in actually identifying and testing the pulses occurred in 2001.



Example of an experimental set up. © Johan Jarnestad/The Royal Swedish Academy of Sciences

Pierre Agostini and his research group in France succeeded in producing and investigating a series of consecutive light pulses, like a train with carriages. They used a special trick, putting the “pulse train” together with a delayed part of the original laser pulse, to see how the overtones were in phase with each other. This procedure also gave them a measurement for the duration of the pulses in the train, and they could see that each pulse lasted just 250 attoseconds.

At the same time, Ferenc Krausz and his research group in Austria were working on a technique that could select a single pulse – like a carriage being uncoupled from a train and switched to another track. The pulse they succeeded in isolating lasted 650 attoseconds and the group used it to track and study a process in which electrons were pulled away from their atoms.

These experiments demonstrated that attosecond pulses could be observed and measured, and that they could also be used in new experiments.

Now that the attosecond world has become accessible, these short bursts of light can be used to study the movements of electrons. It is now possible to produce pulses down to just a few dozen attoseconds, and this technology is developing all the time.

Electrons' movements have become accessible

Attosecond pulses make it possible to measure the time it takes for an electron to be tugged away from an atom, and to examine how the time this takes depends on how tightly the electron is bound to the atom's nucleus. It is possible to reconstruct how the distribution of electrons oscillates from side to side or place to place in molecules and materials; previously their position could only be measured as an average. Attosecond pulses can be used to test the internal processes of matter, and to identify different events. These pulses have been used to explore the detailed physics of atoms and molecules, and they have potential applications in areas from electronics to medicine.

For example, attosecond pulses can be used to push molecules, which emit a measurable signal. The signal from the molecules has a special structure, a type of fingerprint that reveals what molecule it is, and the possible applications of this include medical diagnostics.

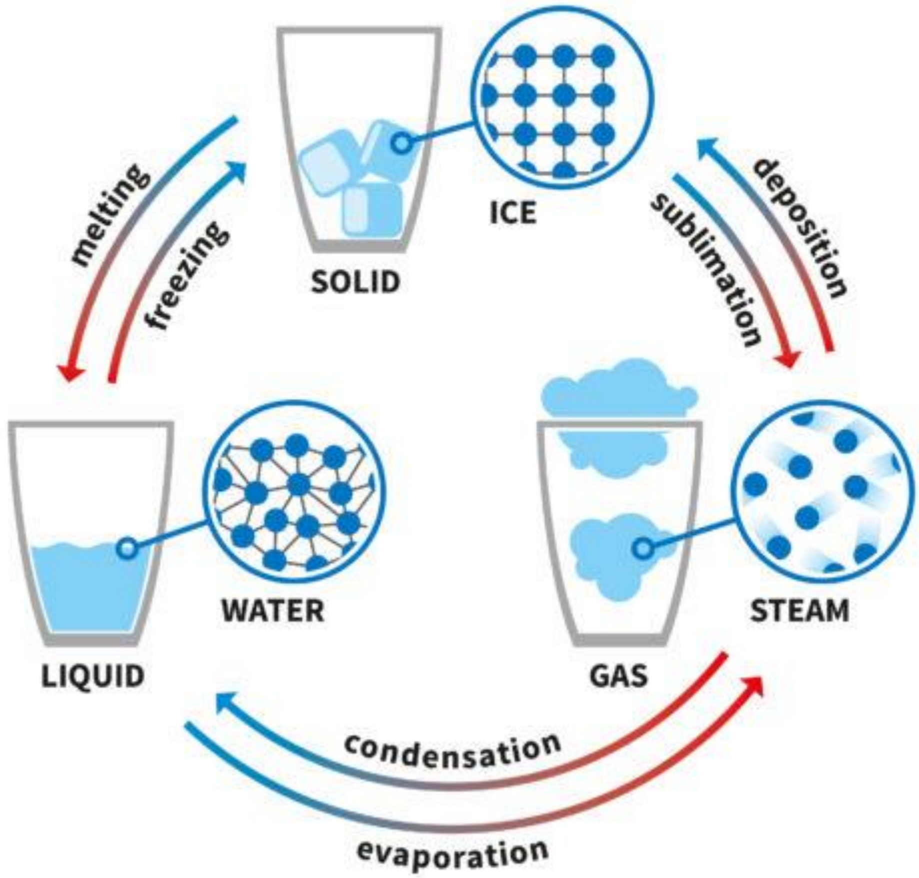
Explainer: What are the different states of matter?

By Allison Gasparini, October 26, 2022 at 6:30 am

Most people know solids, liquids and gases — but what about the four others?

John and Tina Reid/Getty Images,

A geyser in Iceland exhibits the three main states of matter of H_2O. As a liquid, H_2O is known as water. The steam coming off the geyser is the gas form of H_2O, and the surrounding snow shows H_2O in its solid state. Ice, water and vapor are three distinctly different forms or states of water. Like other substances, water can take different forms as its surrounding environment changes. Take, for example, an ice-cube tray. Pour water into the tray, stick it in the freezer and a few hours later that liquid water will have transformed into solid ice. The substance in the tray is still the same chemical H_2O; only its state has changed. Put the ice into a pot over a flame on the stove and it will melt back down to liquid. If it gets hot enough, you will notice steam rising off of the liquid. This vapor is still H_2O, just in gas form. Solid (the ice), liquid (the water) and gas (the vapor) are the three most common states of matter, at least on Earth. In ancient Greece, one philosopher recognized how water could change form and reasoned that everything must be made of water. However, water isn't the only type of matter that changes states as it's heated, cooled or compressed. All matter is made of atoms and/or molecules. When these tiny building blocks of matter change their structure, their state or phase does too.



jack0m/DigitalVision Vectors/Getty Images

this diagram illustrates the cycle of the states of matter using H_2O as an example. The arrows show the name of the process that moves each state of matter into another state. Plus Solid, liquid and gas are the best-known states of matter. But they're not the only ones. Lesser-known states develop under more extreme conditions — some of which never exist naturally on Earth. (They can only be created by scientists in a laboratory.) Even today, researchers are still discovering new states of matter. While there's likely more awaiting discovery, below are seven of the currently agreed-upon states that matter can take.

Solid: Materials in this state have a definite volume and shape. That is, they take up a set amount of space. And they'll maintain their shape without the help of a container. A desk, phone and tree are all examples of matter in its solid form. The atoms and molecules that make up a solid are tightly packed together. They're so tightly bound that they do not move freely. A solid may melt into a liquid. Or it might sublimate turn directly from solid to gas when brought to certain temperatures or pressures.

Liquid: Materials in this state have a definite volume but no defined shape. Squeezing a liquid will not compress it into a smaller volume. A liquid will take the shape of any container into which it's poured. But it will not expand to fill the entire container holding it. Water, shampoo and milk are all examples of liquids. Compared to the atoms and molecules in a solid, those in a liquid are usually less tightly packed together. A liquid could be cooled into a solid. When heated enough, it will usually become a gas. Within the most common phases of matter, other states may appear. For example, there are liquid crystals. They appear to be a liquid and flow like a liquid. Their molecular structure, however, better resembles solid crystals. Soapy water is an example of a common liquid crystal. Many devices make use of liquid crystals, including cell phones, TVs and digital clocks.

Gas: Materials in this phase have no definite volume nor shape. A gas will both take the shape of its container and expand to fill that container. Examples of common gases include helium (used to make balloons float), the air we breathe and the natural gas used to power many kitchen ranges. The atoms and molecules of a gas also move more rapidly and freely than those in a solid or liquid. The chemical bonds between the molecules in a gas are very weak. Those atoms and molecules are also farther apart than those of the same material in its liquid or solid forms. When cooled, a gas may condense into a liquid. For instance, water vapor in air can condense outside a glass holding ice-cold water. This can create tiny water droplets. They can run down the side of the glass, forming small pools of condensation on a tabletop. (That's one reason people use coasters for their drinks.)

Supercritical Fluid: The word "fluid" can refer to a liquid or a gas. Some fluids are supercritical. This is a state of matter that occurs at a critical point of temperature and pressure. At this point, liquids and gases cannot be told apart. Such supercritical fluids occur naturally in the atmospheres of Jupiter and Saturn.

The word "fluid" can refer to a liquid or a gas. But supercritical fluid is a weird in-between state of matter, which looks like both a liquid and a gas. About nine minutes into this video, we learn of potential applications for such a supercritical material.

Plasma: Like a gas, this state of matter has no definite shape nor volume. Unlike gases, however, plasmas can both conduct an electric current and create magnetic fields. What makes plasmas special is that they contain ions. These are atoms with an electric charge. Lightning and neon signs are two examples of partially ionized plasmas. Plasmas are often found in stars, including our sun. A plasma can be created by heating a gas to extremely high temperatures. A plasma may also form when a jolt of high voltage moves across a space of air between two points.

Though they are rare on Earth, plasmas are the most common type of matter in the universe.

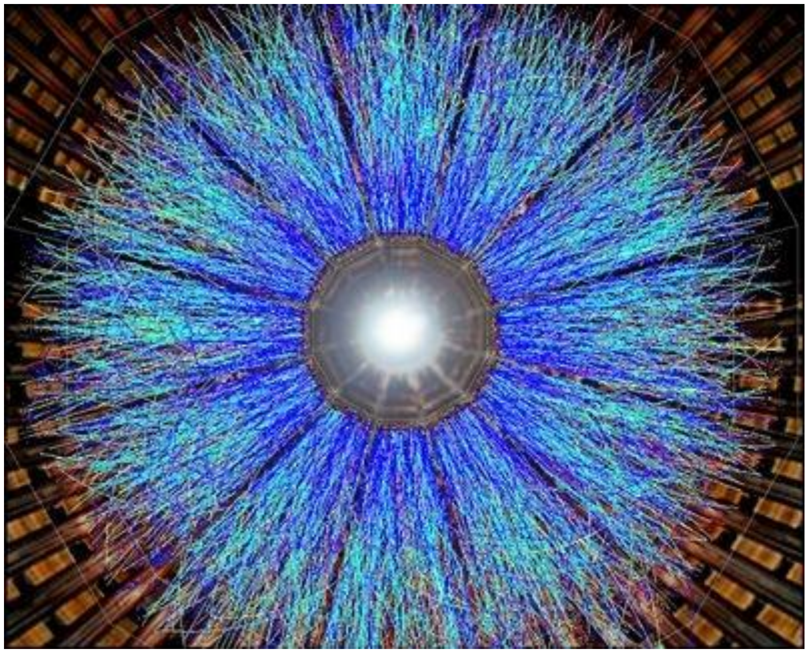
Bose-Einstein condensate: A very-low-density gas that has been cooled to near absolute zero transforms into a new state of matter: a Bose-Einstein condensate. Absolute zero is thought to be the lowest temperature possible: 0 kelvin, –273 degrees Celsius or about –459.67 degrees Fahrenheit. As this low-density gas gets into such a super-cold regime, all of its atoms will eventually begin to "condense" into the same energy state. Once they reach it, they will now act as a "superatom." A superatom is a cluster of atoms that act as if they were a single particle. Bose-Einstein condensates don't develop naturally. They form only under carefully controlled, extreme laboratory conditions.

Degenerate matter: This state of matter develops when a gas is super-compressed. It now begins to act more like a solid, even though it remains a gas. Normally, atoms in a gas will move rapidly and freely. Not so in degenerate matter. Here, they are under such high pressure that the atoms smoosh closely together into a small space. As in a solid, they can no longer move freely. Stars at the end of their lives, such as white dwarfs and neutron stars, contain degenerate matter. It's what allows such stars to be so small and dense. There are several different types of degenerate matter, including electron-degenerate matter. This form of matter contains mostly electrons. Another example is neutron-degenerate matter. That form of matter contains mostly neutrons.

Quark-gluon plasma: As its name suggests, a quark-gluon plasma is made up of the elementary particles known as quarks and gluons. Quarks come together to form particles like protons and neutrons. Gluons act as the "glue" that holds those quarks together. A quark-gluon plasma was the first form of matter to fill the universe following the Big Bang. a blue starburst shape with a bright white centerThis is an artist’s visualization of one of the first full-energy collisions between gold ions at the Brookhaven Relativistic Heavy Ion Collider, as captured by a detector there known as STAR. It would help confirm the features of quark-gluon plasmas.

Scientists at the European Organization for Nuclear Research, or CERN, first detected a quark-gluon plasma in 2000. Then, in 2005, researchers at Brookhaven National Laboratory in Upton, N.Y., created a quark-gluon plasma by smashing gold atoms together at close to the speed of light. Such energetic collisions can produce intense temperatures up to 250,000 times hotter than the sun’s interior. The atom smashups were hot enough to break down the protons and neutrons in the atomic nuclei into quarks and gluons. It had been expected that this quark-gluon plasma would be a gas. But the Brookhaven experiment showed it was actually a sort of liquid. Since then, a series of experiments have shown that the plasma acts as a super-liquid, exhibiting less resistance to flow than any other substance. A quark-gluon plasma once filled the entire universe like a kind of soup from which matter as we know it emerged.

And more? As with liquid crystals and supercritical fluids, there are even more states of matter than those described above. As researchers continue working to understand the world around us, they will likely keep finding newer and stranger ways that atoms, which make up everything in the world around us, behave under extreme conditions.



This is an artist’s visualization of one of the first full-energy collisions between gold ions at the Brookhaven Relativistic Heavy Ion Collider, as captured by a detector there known as STAR. It would help confirm the features of quark-gluon plasmas.

Dopamine determines how reward overrides risk

Why do animals pursue reward in the face of punishment? Dopamine-releasing neurons that promote reward-seeking behaviour indirectly impair those that encode punishment avoidance, affecting decisions on risk.

Nature 623, 258-259 (2023)

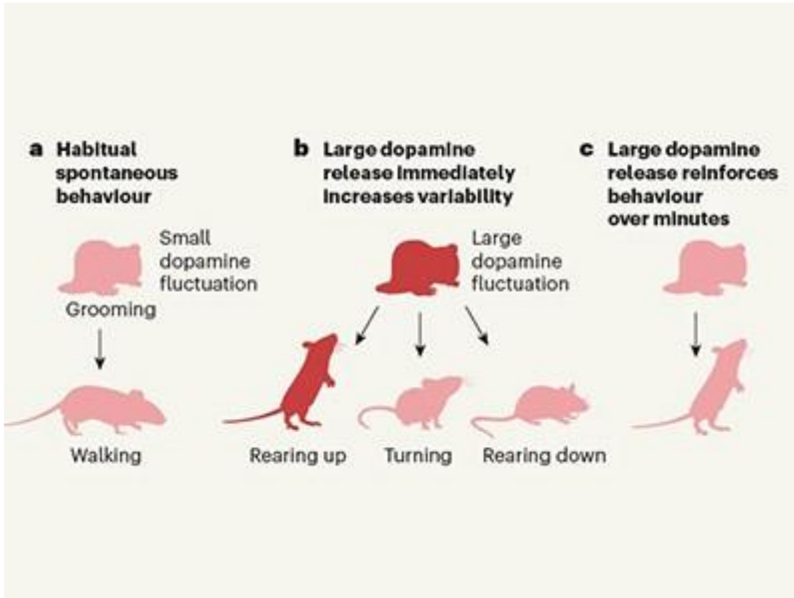
doi: https://doi.org/10.1038/d41586-023-03085-4

The ability to evaluate both risk and reward is necessary for animals to survive in their natural environment. Risk avoidance and reward seeking are influenced by internal state (such as hunger or thirst), environmental context and previous experience, and can have far-reaching effects on mental health. For instance, motivation for reward seeking is often blunted in depression, but enhanced in drug addiction. Furthermore, increased motivation for reward in disorders such as addiction often corresponds with diminished risk avoidance. The precise mechanisms that underlie motivational drives have eluded scientists, owing mainly to the sheer number and diversity of neurons in the brain that reinforce reward seeking and punishment avoidance. Writing in Nature, Jovanoski et al. use neurogenetic tools that provide precise control over a mixed population of dopamine-releasing neurons in the brains of fruit flies (Drosophila melanogaster) to clarify the neural mechanisms behind unconstrained reward seeking the persistent pursuit of reward even in the face of punishment.

A well-characterized region of the fruit-fly brain known as the mushroom body has provided remarkable insight into how memories of experiences are stored, retrieved and updated, as well as why some memories are more enduring than others. This is largely because techniques are now available that allow nearly all of the neurons connected to the mushroom body to be individually manipulated with the temporal precision needed to identify memory circuits and track changes in their activity over time. Some key principles about the neural encoding of rewarding experiences have emerged from research using the fruit-fly mushroom body as a model. Reward encoding depends on the presence, timing and intensity of a reward, or on the absence of an expected punishment.

Dopamine and related neurotransmitter molecules are required for encoding, extinguishing and updating memories. The dopamine neurons that encode reward are diverse in terms of the genes they express, and can be defined according to the anatomical compartments that they occupy within the mushroom body. Although some dopamine neurons seem to be involved in all types of reward, others are apparently specific to a particular reward or internal state necessary for the expression of reward behaviours.

In fruit flies, dopamine is also required for maladaptive memories, such as those associated with an alcohol reward. Fruit flies develop preferences that last up to seven days for cues previously associated with alcohol, and exhibit a form of unconstrained reward seeking by walking over an electric shock to approach an odour that is predictive of an alcohol reward. Although alcohol activates a broad population of dopamine neurons associated with reward, the mechanisms that cause fruit flies to endure electric shocks to attain a reward cue were previously unknown.



Spontaneous behaviour is shaped by dopamine in two ways

Jovanoski et al. used gene-expression patterns to identify a population of dopamine neurons that provide input to the mushroom body. They then artificially activated individual neurons, and were able to establish that these neurons are sufficient to drive unconstrained reward seeking. By associating the artificial activation of this population of dopamine neurons with an odour, the authors showed that fruit flies will tolerate an electric-shock punishment in pursuit of that odour one minute later.

The authors then used genetic tools to identify a subpopulation of these dopamine neurons that, when activated, can artificially instil a shock-resistant reward-seeking behaviour. This subpopulation of dopamine neurons makes connections with discrete regions of the mushroom body that are thought to be necessary for forming short-term associations with sugar and water. The response superseded internal state, because hungry fruit flies pursued an odour associated with artificial activation, rather than satiating their hunger with sugar.

Jovanoski and colleagues also describe a network of opposing reward- and punishment-encoding dopamine neurons responsible for behavioural choice. The reward dopamine neurons indirectly impair the function of the punishment dopamine neurons, and this drives unconstrained reward seeking (Fig. 1). These data resolve how the processing of signals that drive opposing behaviours influences future decisions about risk, and add a fundamental principle through which reward is assessed and drives motivated behavior.

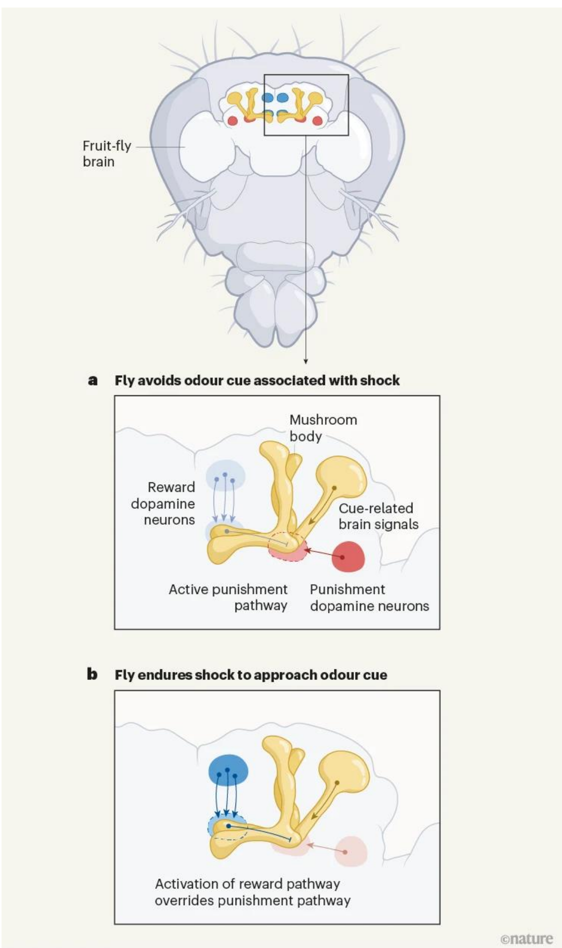


Figure 1 | Dopamine-releasing neurons drive the pursuit of reward in the face of punishment. Jovanoski et al.5 show that, in a region of the fruit-fly brain called the mushroom body, distinct subpopulations of neurons that release the neurotransmitter dopamine can reinforce either the seeking of a reward or the avoidance of a punishment. a, Typically, the activity of punishment-encoding neurons (red) overcomes that of reward-encoding neurons (blue), causing fruit flies to *avoid an odour cue associated with an electric shock. b, When the odour cue is paired with artificial stimulation of reward-encoding neurons, however, fruit flies will endure an electric shock in pursuit of the odour. Dysregulation of a similar network of opposing dopamine neurons in humans* could be responsible for unconstrained reward-seeking behaviour, a feature of addiction.

This work was possible because subpopulations of dopamine neurons within a heterogeneous dopamine reward system could be identified and manipulated, and combining this with approaches that map neural connections showed that these subpopulations receive diverse and highly parallel inputs. The authors' findings reveal the complexity of reward encoding and the role of functionally interconnected brain compartments in representing multiple reward types that are gated by a variety of motivational states, including thirst and hunger. Future studies might address how long aberrant behavioural choices persist, and whether these mechanisms occur in the face of more intense rewards, such as intoxicating substances.

Given that there are strong parallels between the reward circuitry of fruit flies and that of mammals, Jovanoski and colleagues' work provides a fundamental framework for understanding how animals remember rewards and overcome aversive stimuli to seek them. One caveat is that the study uses data averaged from groups of fruit flies, and is therefore not able to address recurrent or compulsive reward-seeking behaviour, which would need to be examined in individual animals. However, a similar internal-state-gated network of opposing dopamine neurons could explain how unconstrained reward seeking occurs in addiction. Further investigation of this network could improve our understanding of depression, addiction and other mental-health disorders in which the balance between risk and reward is disrupted.

Scientists get Rare Glimpse of 'Nesting Doll' Isotope Nitrogen-9

03 November, 2023 | by Ben Turner

Source website link: https://www.livescience.com/chemistry/scientists-get-rare-glimpse-of-nesting-doll-isotope-nitrogen-9

With five more protons than should be stable, the newly discovered nitrogen-9 isotope sits right on the borderline of physical possibility.

Scientists may have just caught their first glimpse of an ultra-rare version of nitrogen containing five more protons than it can stably hold. Scientists discovered hints of the new isotope, called nitrogen-9, by smashing beams of oxygen isotopes into beryllium atoms in the U.S. National Superconducting Cyclotron Laboratory.

If follow-up experiments can confirm its existence, the isotope will set a new record for an atomic nucleus with the highest number of extra protons — moving the number from four to five. The researchers described the strange new isotope Oct. 27 in the journal Physical Review Letters.

The ultra-unstable version of nitrogen decays like a Russian nesting doll, sequentially emitting one or two protons while revealing the next set, Robert Charity, a nuclear scientist at Washington University in St. Louis, said in a statement.

Protons and neutrons are held together inside atomic nuclei by the strong force, a glue which in stable atoms overpowers the repulsive force of positively-charged protons pushing against each other. But add more protons and this balance eventually tips — moving atoms beyond the so-called "drip line." Beyond the drip line atoms become unstable, and decay by chucking out protons or neutrons. Because they exist on the furthest edge of possible atomic nuclei, semi-stable atoms beyond the drip line (which come in the form of rare isotopes) have long fascinated nuclear scientists.

"The existence of such an exotic system is a good test of the quantum mechanics of open or unbound many-body systems," Charity said. The researchers found the first hints of nitrogen-9's presence in data from a years-old experiment conducted by the National Superconducting Cyclotron Laboratory. Originally, the scientists

smashed oxygen-13 atoms into beryllium in a bid to create another isotope called oxygen-11.

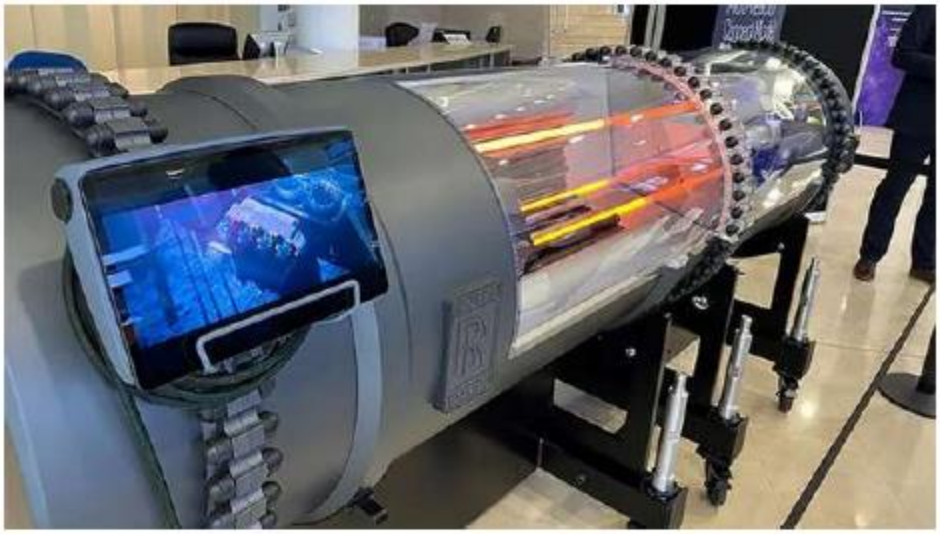
But lurking among the millions of interactions was another decay signature that pointed to something else. Right on the borderline of statistical significance, the researchers spotted rare atoms of nitrogen-9 popping into existence for just 10^{-21} seconds. To get partial confirmation they had found the weird isotope, the scientists modeled the isotope's structure, finding that it consisted of a helium nucleus with two protons and two neutrons surrounded by five loosely held protons. After the briefest slice of time the protons decayed, successively escaping the nucleus through a quantum tunnel.

Further experiments will be needed to confirm the discovery. They remain hopeful that, when they do, the isotope will help them to piece together the decay paths more common isotopes take to come into existence. "The elements we have around us are made via a set of mechanisms that work through intermediates that we do not have around us," Lee Sobotka, a professor of chemistry and physics at Washington University, said in the statement. "These intermediates are unstable and often have highly unusual neutron-to-proton ratios. Our work involves both reconstructing the structure of, and reactions producing, such nuclei."

Nuclear Power on the Moon: Rolls-Royce Unveils Reactor Mock-up

07 December, 2023 | by Tereza Pultarova
Source website link: https://www.space.com/moon-rolls-royce-nuclear-reactor-concept-unveiled

The company hopes to have a demo device ready for a moon trip in 2029.



A mockup of Rolls-Royce's planned nuclear reactor that could power an outpost on the moon. (Image credit: Rolls-Royce)

The U.K. tech giant Rolls-Royce has unveiled a concept nuclear reactor that could power a future outpost on the moon. The mini reactor, which appears to be about 3.3 feet (1 meter) wide and 10 feet (3 m) long, is not yet capable of producing any electricity, and it will take about six years and a few million dollars to get it ready for its debut space trip, if all goes according to plan. The U.K. Space Agency awarded Rolls-Royce £2.9 million ($3.7 million U.S. at current exchange rates) in March of this year to fund the development of the potentially groundbreaking moon tech, a mockup of which was unveiled at the U.K. Space Conference in Belfast last month.

"This funding has enabled crucial research and development of technologies that bring us closer to making the Micro-Reactor a reality," Abi Clayton, director of future programs at Rolls-Royce, said in a statement on Friday (Dec. 1). "Our Space

Micro-Reactor Concept Model allows us to demonstrate how this technology will bring immense benefits for both space and Earth."

The reactor will rely on nuclear fission, the same process that enables Earth-based nuclear power plants to generate electricity. Most moon missions, including the rovers launched recently by China and India, have used solar energy as a power source, but that strategy has obvious limitations, as the moon is plunged into darkness for two weeks every month. Russia's 1970s Lunokhod rovers also relied on solar power while NASA's Apollo missions used hydrogen fuel cells to power the pioneering human lunar landings. A simpler, less potent source of nuclear power used in spaceflight are radioisotope thermoelectric generators (RTGs). Those nuclear batteries rely on the natural process of radioactive decay, in which a less stable nucleus changes into a more stable one over time, releasing energy in the process.

RTGs last a long time but don't produce enough power to keep a crewed mission going. The process of nuclear fission, on the other hand, splits a large atomic nucleus into smaller fragments. The reaction produces much more energy than simple decay but requires an external source of energy to kick-start it.

The new moon reactor will have a modular design, Rolls-Royce said, and have many possible uses on Earth as well. "Micro-Reactor technology will deliver the capability to support commercial and defense use cases alongside providing a solution to decarbonize industry and provide clean, safe and reliable energy," Clayton said in the statement.

Rolls-Royce engineers are currently investigating methods that will enable the heat generated by the reactor through nuclear fission to be converted into electricity. In conventional nuclear reactors on Earth, this heat boils water, which then turns into a pressurized steam that turns a turbine. Such a system, however, might be a little too complex for a space-fit piece of tech.

"This innovative research by Rolls-Royce could lay the groundwork for powering continuous human presence on the moon, while enhancing the wider U.K. space sector, creating jobs and generating further investment," Paul Bate, chief executive of the U.K. Space Agency, said in the same statement.