ISAS INDIA *Newsletter*

Volume 22 , No. 4 *Oct-Dec, 2022*

Dear ISAS Members

It gives us immense pleasure in bringing the last issue of the year. Hope you all must be fine and enjoying reading ISAS newsletter. In continuation we are bringing this issue.

The 2022 Nobel Prize for Chemistry has been jointly awarded to three researchers: Carolyn Bertozzi, for her development of bioorthogonal chemistry, and Morten Meldal and K. Barry Sharpless, for their independent development of click chemistry. Click chemistry has enabled massive strides in drug development, DNA sequencing, the synthesis of "smart" materials. Alain Aspect, John Clauser and Anton Zeilinger have won the 2022 Nobel Prize in Physics for groundbreaking

experiments establishing the existence of a bizarre quantum phenomenon known as entanglement, where two widely separated particles appear to share information. Jian-Wei Pan et al, launched a satellite named Micius in 2016. Micius beamed pairs of photons to labs in China that were separated by more than 1,000 kilometers. India sees small modular reactors in its clean energy future. For first time U.S. scientists have created a holographic wormhole and sent a message through it. Indian Scientists Devise New Concept in Same Field in which Physics Nobel Awarded i.e. of quantum information science (QIS) and entangled photons. Quantum information science (QIS) is the study of applying quantum mechanics to computing, communication, sensing, and simulation. India's Mars Orbiter Mission is finally out of fuel after 8 years of science operations. Union Minister Dr. Jitendra Singh opines that Science has turned yesterday's fairy tales into today's reality and therefore optimum mix of traditional knowledge with modern research can result in outcomes beyond imagination. The Indian Space Research Organisation (ISRO) has successfully tested the indigenously developed cryogenic engine that will power its heaviest rocket, the LVM-3. Purdue University chemists have discovered a mechanism for peptide-forming reactions to occur in water — something that has baffled scientists for decades. This is essentially the chemistry behind the origin of life. One article is devoted to the evolution of the periodic table from a sketch to an enduring masterpiece. Shocking Experiment Indicates Our Brains Use Quantum Computation. Quantum brain processes could also explain why humans can still outperform supercomputers when it comes to unforeseen circumstances, decision-making, or learning something new. Designer Molecules' could Create Tailor-made Quantum Devices. By carefully tailoring the composition of molecules, researchers are creating chemical systems suited to a variety of quantum tasks. World's first optical atomic clock with highly charged ions, have been realized based on thirteen-fold charged argon ions.

Dr. Pradeep Kumar

Chief Editor

ISAS Newsletter

Message from President, ISAS

Happy to see that the latest ISAS Newsletter for October-December is ready for release.

Wish you all a happy reading of this ISAS News Letter.

ISAS, during the term of this EC, registered a magnificently Outstanding Performance Record, that was achieved due to Dynamic Leadership, Swift Policy Decisions, Out of the Box Thinking leading to a Variety of Productive Activities. Of course, such a performance efficiency has to be achieved through top class management approach, by over ruling of some mere clerical approaches that tried to interfere, insult and delay.

Such a high performance records included Committed Efforts to Streamlining the Upkeep of ISAS Records; Updating the ISAS Membership List; Creating and Operating an Impressive ISAS Website (isasbharat.in); Embarking on the ISAS Journal (which is first of its kind in India); Conducting Two Indian Analytical Science Congresses (IASC-2019 and IASC-2022) and embarking upon the third IASC (IASC-2023); Organizing the vibrant AKAM Series of 75 Weekend ISAS Webinars overcoming the limitations imposed by the Covid Pandemic; Elevating

the Status of ISAS as a Professional Body by Instituting many ISAS Awards that included The ISAS Analytical Scientist of the Year Award, starting from 2019-20, the ISAS Sastra Pitamaha Award, the ISAS Atma Nirbharta Award, ISAS Homi Bhabha Award, ISAS Raja Ramanna Award, ISAS Dr M.Sundaresan Memorial Award, ISAS Awards for Indian Analytical Instrument Manufacturers, ISAS Hon.Fellowships to Outstanding Indian Scientific Performers, etc.

ISAS could set such an Excellent Functional Track Record, only by adopting a Top Class Management Approach and weeding out mere low class clerical interferences that attempted to impose very embarrassing traffic jams in the bright royally Glorious High Way of Professional Performance of ISAS.

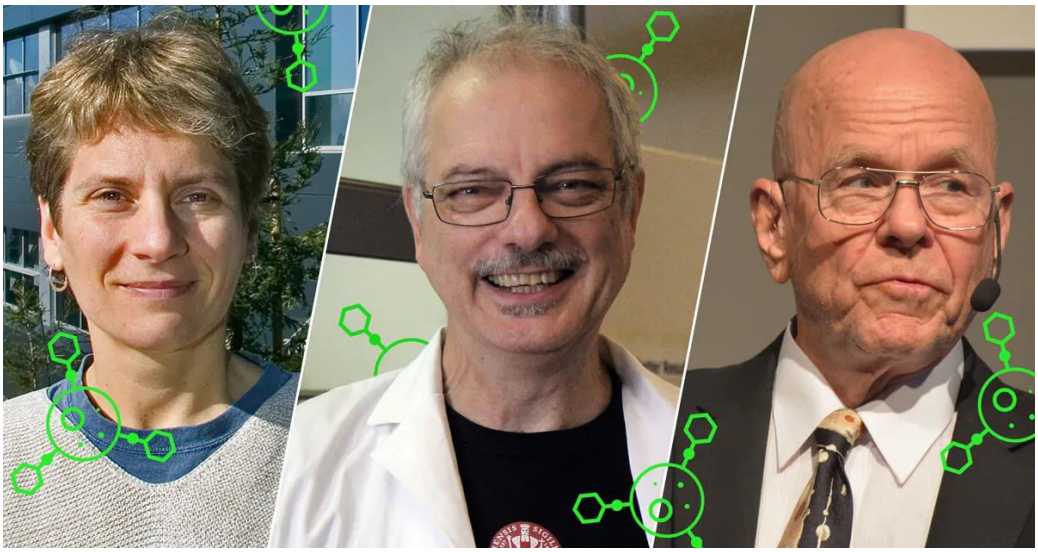
I take this opportunity to Wish All The ISAS Fraternity an all round Grand Professional and Personal Success, when they enter into the New Year, 2023.

(Dr. P. P. Chandrachoodan)
President,
ISAS.

Molecule-Building Innovators Win Nobel Prize in Chemistry

Source:/www.quantamagazine.org/molecule-building-innovators-win-2022-chemistry-nobel-prize-20221005/

The 2022 Nobel Prize for Chemistry has been jointly awarded to three researchers: Carolyn Bertozzi, for her development of bioorthogonal chemistry, and Morten Meldal and K. Barry Sharpless, for their independent development of click chemistry.



Carolyn Bertozzi, Morten Meldal and K. Barry Sharpless have been awarded the 2022 Nobel Prize in Chemistry for the development of click chemistry and bioorthogonal chemistry. Click chemistry revolutionized the options available to chemists for creating the molecules they desired. Bioorthogonal chemistry made it possible to monitor the chemical processes going on inside living cells without harming them.

“It’s all about snapping molecules together,” said Johan Åqvist, chair of the Nobel Committee for Chemistry, during the announcement. Imagine, he told the audience, that you could attach small chemical buckles to a bunch of different types of molecular building blocks and then link these buckles together to produce

complex molecules. That idea, put forth by Barry Sharpless of the Scripps Research Institute about 20 years ago, later became reality when he and Morten Meldal of the University of Copenhagen independently found the first perfect candidates for the job. Their buckles easily snapped together and wouldn't link onto anything they shouldn't.

Then, in 2003, Carolyn Bertozzi proposed that click chemistry could be used in studies of biological systems to make it easier to observe vital cellular processes without interfering with them. Bertozzi called this "bioorthogonal" chemistry in a paper she and her colleagues published that year. The term has since been widely-adopted term in the field.

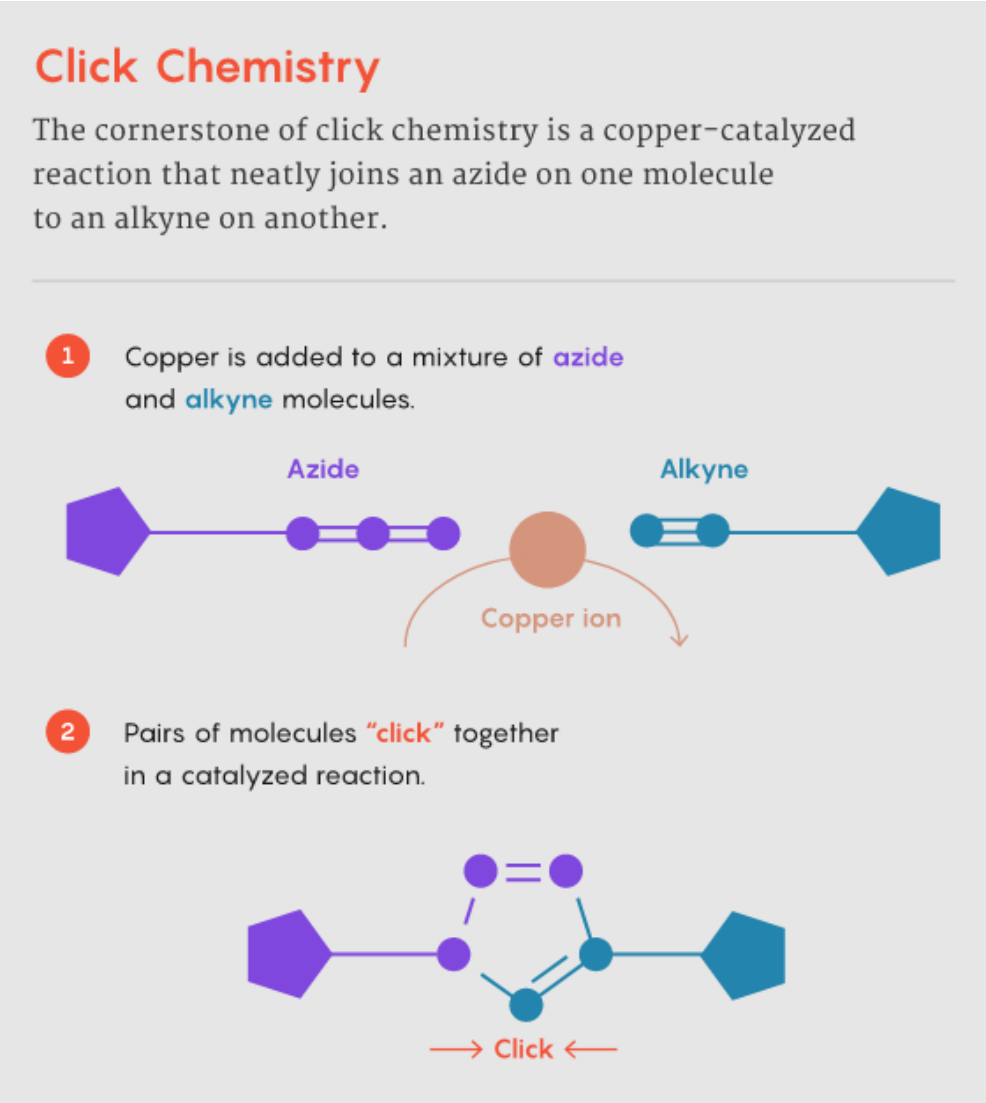
The ability to perform complex reactions in living systems without interfering with natural biological reactions made it possible to study molecules and cellular processes in cells and inside complex organisms such as zebra fish, rather than in laboratory dishes. It has already helped scientists understand an important protein processing reaction called glycosylation, helped to develop molecular imaging molecules that could detect disease in living organisms, and opened up the possibility of selectively delivering drugs to particular tissues in the body.These findings have "led to a revolution in how chemists think about linking molecules together and how to do it in living cells," Åqvist said.

Today's announcement marks the second time that Sharpless has won a Nobel Prize in Chemistry. In 2001, he shared the prize with William Knowles and Ryoji Noyori for the development of catalytic asymmetric synthesis.

What is click chemistry?

Sharpless spent much of the 1990s considering the need to find less cumbersome ways to synthesize complex molecules. His thinking culminated in a 2001 paper in

which he and his co-authors proposed the term “click chemistry” to refer to any reaction that links together molecular building blocks in an efficient, specific and quick manner. Shortly after the publication of the paper, Meldal and Sharpless independently discovered the first click chemistry reaction: a highly useful one called the copper-catalyzed azide-alkyne cycloaddition.



On one side of the reaction is an azide, a molecule that has three nitrogen atoms in a row. On the other side is an alkyne, a molecule in which two carbon atoms are bonded together with a triplet bond. By themselves, these two building blocks aren’t very reactive: Mixed together, they are slow to react and yield a mixture of

products. But Meldal and Sharpless separately realized that if they added a bit of copper to the mix, the reaction accelerated dramatically and led primarily to a stable product known as a triazole. By strategically adding azide and alkyne "tags" to molecules, chemists can use this copper-catalyzed reaction to link them precisely into much larger molecules with specific structures.The copper-catalyzed reaction immediately gained "enormous interest" across chemistry and related fields, said Olof Ramström of the Nobel committee during the announcement. Although other click chemistry reactions have been found, "this particular reaction has almost become synonymous with the click chemistry concept and is also often called the click reaction," Ramström said. "You can say that it's still the crown jewel of click reactions."

How is bioorthogonal chemistry used to study living systems?

Bertozzi came up with a simple way to track glycans on a cell. First, she grew cells near a modified sugar that was linked to an azide. The cells up took up the modified sugar and incorporated it into glycans on their surface. Then Bertozzi added to the mixture an alkyne that had a fluorescent molecule attached to it. The alkyne underwent a click reaction with the modified sugar and attached the fluorescent molecule to it. With that simple reaction, the glycans glowed green, and that allowed Bertozzi to track their movements across cell membranes under a microscope.

Today, Bertozzi, a professor at Stanford University, tracks glycans found on the surface of tumor cells. This work enabled her to discover that certain glycans protect tumor cells from the body's immune system. Her findings have opened up avenues for cancer immune therapy, with many researchers working to find "clickable" antibodies to target different types of tumors. Bertozzi and her team are

also working on this problem. They have created a new drug, currently in clinical trials, that targets and destroys glycans on the surface of tumor cells

What are other applications for click chemistry and bioorthogonal chemistry?

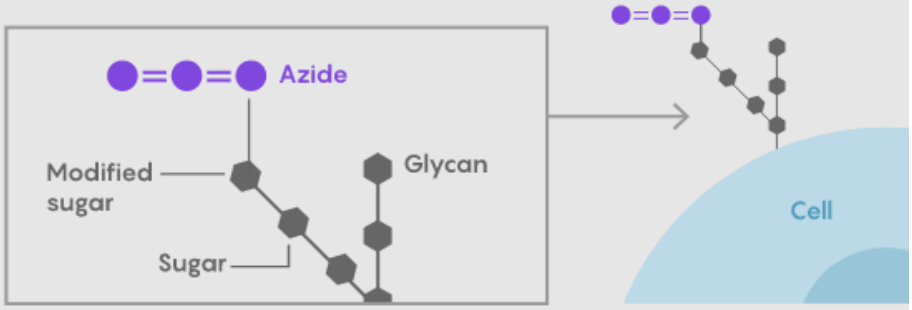
Tracking the movements of molecules through and across cells is just one of many applications for click chemistry and bioorthogonal chemistry. A major advantage of the techniques is that they don't introduce unwanted byproducts into reaction mixtures — they function with a clean efficiency that allows scientists to carefully craft complex molecules for a variety of purposes. Click chemistry has enabled massive strides in drug development, DNA sequencing, the synthesis of "smart" materials and almost any other application in which chemists need to simply connect pairs of building blocks, Ramström said. Researchers can now easily add functionality to a wide range of materials, for example by clicking in chemical extensions that can conduct electricity or capture sunlight.

Bioorthogonal reactions are used widely to investigate vital processes in cells, and those applications have had an enormous impact on the fields of biology and biochemistry. Researchers can probe how biomolecules interact within cells, and they can image living cells without disturbing them. In studies of disease, bioorthogonal reactions are useful for studying not just the cells of patients but also those of pathogens: The proteins in bacteria can be labeled to follow their movements through the body. Researchers are also starting to develop engineered antibodies that can click onto their tumor targets to deliver cancer-killing therapeutics more precisely."These very important accomplishments and these really fantastic discoveries from our three laureates have really made an enormous impact on chemistry and on science in general," Ramström said. "For that, it's really been to the greatest benefit of humankind."

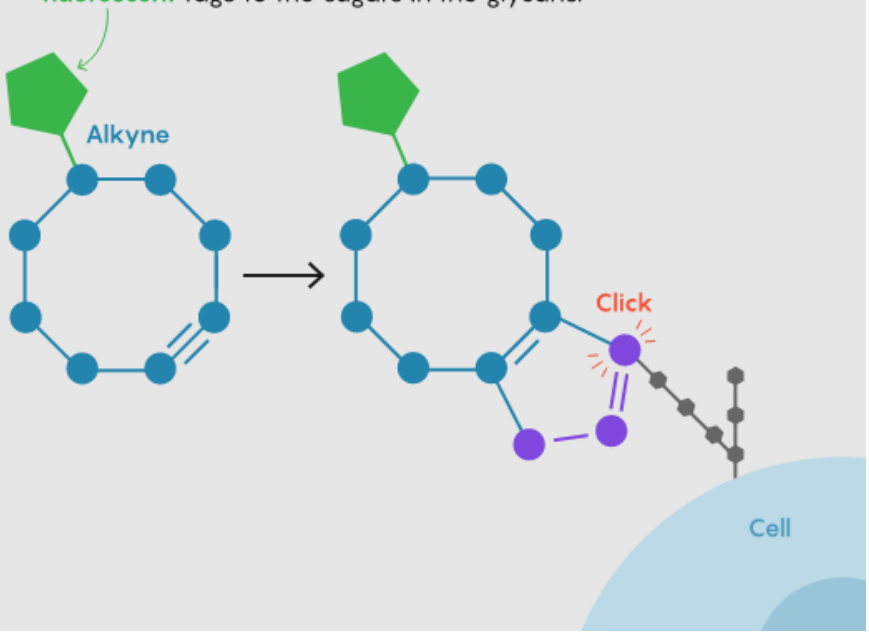
Tracking Cellular Molecules

To follow the movements of molecules like the glycans on cell surfaces, researchers can use bioorthogonal chemistry to tag them with markers.

1 Modified **sugars** eaten by cells go into the **glycans** the cells make.



2 Click chemistry reactions can attach fluorescent tags to the sugars in the glycans.



Pioneering Quantum Physicists Win Nobel Prize in Physics

https://www.quantamagazine.org/pioneering-quantum-physicists-win-nobel-prize-in-physics-20221004/

Alain Aspect, John Clauser and Anton Zeilinger have won the 2022 Nobel Prize in Physics for groundbreaking experiments with entangled particles.

The physicists Alain Aspect, John Clauser and Anton Zeilinger have won the 2022 Nobel Prize in Physics for experiments that proved the profoundly strange quantum nature of reality. Their experiments collectively established the existence of a bizarre quantum phenomenon known as entanglement, where two widely separated particles appear to share information despite having no conceivable way of communicating.

Entanglement lay at the heart of a fiery clash in the 1930s between physics titans Albert Einstein on the one hand and Niels Bohr and Erwin Schrödinger on the other about how the universe operates at a fundamental level. Einstein believed all aspects of reality should have a concrete and fully knowable existence. All objects — from the moon to a photon of light — should have precisely defined properties that can be discovered through measurement. Bohr, Schrödinger and other

proponents of the nascent quantum mechanics, however, were finding that reality appeared to be fundamentally uncertain; a particle does not possess certain properties until the moment of measurement.

Entanglement emerged as a decisive way to distinguish between these two possible versions of reality. The physicist John Bell proposed a decisive thought experiment that was later realized in various experimental forms by Aspect and Clauser. The work proved Schrödinger right. Quantum mechanics was the operating system of the universe. “I would not call entanglement ‘one,’ but rather ‘the’ trait of quantum mechanics,” Thors Hans Hansson, a member of the Nobel committee, quoted Schrödinger as writing in 1935. He observed, “The experiments performed by Clauser and Aspect opened the eyes of the physics community to the depth of Schrödinger’s statement, and provided tools for creating and manipulating and measuring states of particles that are entangled although they are far way.”

In addition to its paradigm-shattering philosophical implications, entanglement is now poised to power an emerging wave of quantum technologies. Zeilinger has been at the forefront of the field, developing techniques that use entanglement to achieve astounding feats of quantum networking, teleportation and cryptography. “Quantum information science is a vibrant and rapidly developing field. It has broad potential implications in areas such as secure information transfer, quantum computing, and sensing technology,” said Eva Olsson, another member of the committee. “Its predictions have opened doors to another world, and it has also shaken the very foundations of how we interpret measurements.”

What is quantum entanglement?

Two particles are entangled when together they form one quantum system, regardless of the distance between them. To understand this kind of quantum

connection, consider two electrons. Electrons have a quantum property called spin, which, when measured, can take one of two values, referred to as “up” or “down.” Measuring the spin of each electron is like tossing a coin: It will randomly come out up or down. Now imagine that two physicists, Alain and John, each receive a series of coins in the mail. As each pair of coins arrives, the physicists flip them at the same time. Alain might get the sequence heads, tails, tails, heads, tails. And John might get heads, heads, tails, tails, tails. The outcome of Alain’s and John’s coin tosses will have nothing to do with each other. But if they repeat this experiment with a series of entangled electrons instead of coins, they’ll get a strange result: Each time Alain measures an electron that’s spin-up, John will find that his corresponding half of the electron pair comes out spin-down, and vice versa. The two acts of measurement are connected, almost as if flipping one coin could send out a signal that instantaneously ensured the proper outcome of its distant partner at the precise moment of measurement.

It was Einstein, along with Boris Podolsky and Nathan Rosen, who first described quantum entanglement in a now-infamous 1935 paper. The phenomenon, the effects of which Einstein disparagingly dubbed “spooky action at a distance,” was an unavoidable consequence of the nascent theory of quantum mechanics. Einstein suspected that entanglement would prove the death knell of quantum mechanics because it seemed to fly in the face of a central tenet of relativity — that no information could travel faster than the speed of light. No measurement of one electron should be able to instantly influence a measurement in some distant place.

Instead, their paper would lay the foundation for a complete rethinking of reality and a radical new field of research.

How do you measure entanglement?

By the 1930s, it was clear that Bohr, Schrödinger and the other quantum pioneers were onto something; the theory described experiments with atoms and subatomic particles more accurately than any other theory. The debate was how far one could trust it. Einstein, for instance, held out hope that the bizarre theory was just a steppingstone on the way to a more complete picture that would philosophically align with classical physics. He suspected that two entangled electrons took on opposing spins because some "hidden variable" caused their spins to point in opposite directions in the first place. *In other words, what looked like a random measurement outcome in quantum mechanics was actually the result of some as yet unappreciated deterministic description that created an illusory connection between the particles.*

In 1964, John Stewart Bell proposed an experiment that could settle the debate. The details are rather involved, but the general idea was for two physicists to measure the spins of entangled particles along different axes: not just up and down but sometimes, randomly, left and right or in other directions. If Einstein was right, and the particles secretly had predetermined spins all along, then the act of switching the axis of measurement should have no effect on the outcome. Bell calculated that if the universe was truly quantum mechanical, and entanglement was as spooky as it seemed, the axis-switching would lead to correlated spin measurements more often than would be possible in classical theories like relativity. "John Bell translated the philosophical debate into science and provided testable predictions that launched experimental work," said Olsson.

Who performed Bell's experiment?

John Clauser, of Lawrence Berkeley National Laboratory and the University of California, Berkeley, and Stuart Freedman, a graduate student, were the first to take Bell's experiment from the page into the lab. Clauser realized that the experiment would be more feasible if it involved not spinning electrons but polarized photons — particles of light. Like the spin direction of an electron, the polarization of a photon can take on one of two values relative to the orientation of a filter. Polarized sunglasses, for example, block photons that are polarized one way and let in photons polarized in the other manner.

Initially, physicists including Richard Feynman discouraged Clauser from pursuing the experiment, arguing that quantum mechanics needed no further experimental proof. But Bell personally encouraged Clauser to see the research through, and in 1972 Clauser and Freedman succeeded in realizing Bell's experiment. They generated pairs of entangled photons and used lenses to measure their polarization directions. Unsure what he would find, Clauser had placed a $2 bet that his experiment would prove Einstein right. To his surprise, his results vindicated Bell's prediction over Einstein's. The photons' states appeared correlated in a way that precluded any hidden-variable theory. Clauser's lost bet was a huge victory for quantum mechanics. "I was very sad to see that my own experiment had proven Einstein wrong," he said years later in an interview. But Clauser's evidence still wasn't ironclad. His experiment used fixed orientations of the lenses, allowing for a loophole: If a hidden variable that coordinates the photons' polarizations somehow depends on the experimental positioning of the lenses, Einstein could yet be right.

Enter Alain Aspect. He carried out a series of increasingly stringent Bell tests in Paris, culminating in a devilishly sophisticated experiment in 1982. In that test, the

orientation of the lenses would randomly change during the billionths of a second that the photons spent flying from the emitter to the lens. In this way, the initial lens configuration was erased and could have no influence on any secret process setting the polarization at the moment of their emission. Once more, the experiment found in favor of Bell and quantum mechanics.

Only the slimmest of loopholes remained. Could a secret and nonrandom process that was somehow set in motion at the beginning of the experiment determine how the lenses would update? Anton Zeilinger's research at the University of Vienna further narrowed this remaining sliver of doubt. In a 2017 experiment, he led a team that used the colors of photons emitted from distant stars hundreds of years ago to determine the settings of the experiment. If some cosmic conspiracy was creating the illusion of entanglement, it would have had to begin centuries before the births of the experimenters. Some physicists still float theories that maintain Einstein's dream. Superdeterminism, for instance, holds that every detail of the universe's fate, down to the spin and polarization of every last particle, was completely fixed at the Big Bang — before the stars (or Zeilinger's cosmic Bell test) formed. But most researchers take the work of Bell, Clauser, Aspect, Zeilinger and their teams at face value. Entanglement is what it seems: The pair of particles is one unified system. For each individual particle, properties like spin and polarization really are undefined until the moment of measurement. In other words, reality has no fixed and predetermined state until you measure it. It's a dramatic conclusion that most researchers accept but still struggle to fully grasp.

"The very fundamental question — what does this really mean in a basic way? — is unanswered, and is an avenue for new research," said Zeilinger.

What is entanglement good for?

In the nearly 90 years since Einstein tried to kill quantum mechanics by highlighting the absurdity of entanglement, the phenomenon has become much more than fodder for philosophical debates. It's one of the main engines driving the booming field of quantum information science."Physicists are now starting to understand that entanglement and Bell pairs [are] a quantum resource that you can use to achieve amazing new things," said Hansson. Zeilinger is one of the central figures leading the effort to work technological miracles with entanglement. In 1997, he and his colleagues were the first to pull off a feat known as quantum teleportation, which uses a precise protocol of measurements on entangled particles to transfer the polarization direction of one particle over to another without the researchers ever learning the polarization direction that was transported. The technique may come to play a crucial role in quantum computing. "It is not like in the Star Trek films or whatever, transporting something — certainly not a person — over some distance," Zeilinger said by phone during the Nobel announcement. "The point is, using entanglement, you can transfer all the information that is carried by an object over to another place, where the object is, so to speak, reconstituted.

Zeilinger also developed a procedure called entanglement swapping, involving the emission of two entangled Bell pairs, for a total of four particles. When you perform a particular measurement on two of the particles that are not entangled, the remaining two become entangled with each other. Swapping entanglement from particle to particle in this way could help link nodes in a quantum communication network. In a landmark 1998 publication, Zeilinger and his collaborators demonstrated the ability to swap entanglement between photons that had never been in contact with each other.

In recent years, such technologies have left the lab and entered the real world. Jian-Wei Pan, a former student of Zeilinger's, heads up a Chinese group that launched a satellite named Micius in 2016. *Micius beamed pairs of photons to labs in China that were separated by more than 1,000 kilometers.* The group's measurements proved that entanglement had survived the journey. Pan's group later worked with Zeilinger's group in Austria to distribute pairs of entangled particles across the Eurasian continent. This long-distance entanglement distributed a secret message, a so-called quantum key, which gets destroyed by any attempt to intercept the information. The demonstration paves the way for essentially unbreakable cryptography, which will be guaranteed by the thoroughly tested fundamentals of quantum mechanics.

India sees SMRs in its Clean Energy Future

28November, 2022 by World Nuclear News

India's Minister of State Jitendra Singh has called for the country's private sector companies and start-ups to take part in the development of small modular reactor (SMR) technology. The minister's comments were made in an address to a workshop on SMRs held by the government's NITI Aayog policy think-tank.

Jitendra Singh addressed the workshop by video (@DrJitendraSingh)

Prime Minister Narendra Modi has laid down the roadmap for clean energy transition through "bold climate commitments" which are reflected in India's updated nationally determined contributions - the NDCs - under the Paris climate agreement, Singh told the workshop. India has already "taken steps" for a clean-energy transition with aims to achieve net-zero by 2070, he said. "Nuclear, in terms of baseload power, can now play a big role in the decarbonisation strategy and it is in this context that the role of nuclear energy will be critical for clean energy transition, not just of India but for the entire world," he said. "Small modular reactors - the SMRs, as we call them - with up to 300 MW capacity, by nature are flexible in design and require a smaller footprint," he said.

Their "mobile and agile technology" means that SMRs can be factory built - unlike conventional nuclear reactors that are built on site - and also offer significant savings in terms of both cost and shortened construction times, he added. "SMRs are a promising technology also in industrial decarbonisation, especially where there is a requirement of reliable and continuous supply of power.

Source website links:

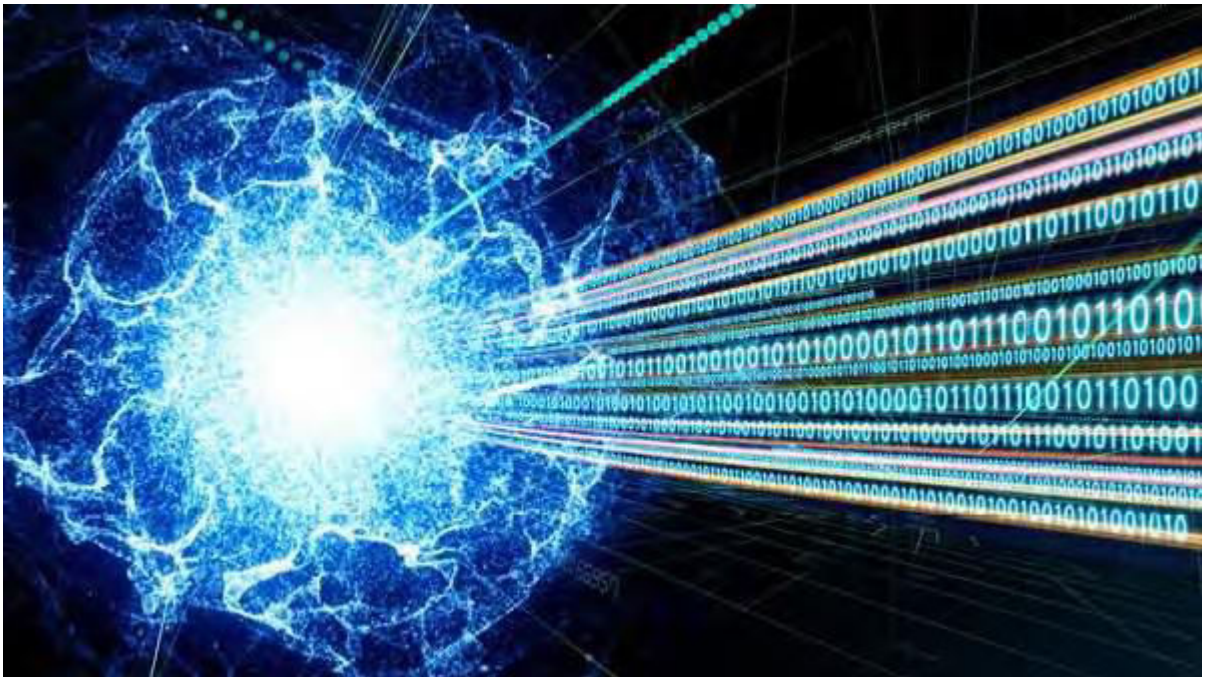
https://www.world-nuclear-news.org/Articles/India-sees-SMRs-in-its-clean-energy-future

In a First, Scientists Create a Holographic Wormhole and Sent a Message Through It

30 November, 2022 | by Ameya Paleja

This could help us probe into the lesser-known field of quantum gravity.A collaborative team of researchers in the U.S. created a holographic wormhole and sent a message through it. This is the first known report of a quantum simulation of a holographic wormhole on a quantum processor. Einstein's theory of general relativity helps us to understand the physical world such as astronomical objects

with high energies or matter densities. Quantum mechanics on the other hand, describes matter at atomic and subatomic scales.However, the two theories are fundamentally incompatible and the holographic principle is a guide that can help us combine the two. According to this principle, theories that include both quantum mechanics and gravity can be exactly equal to those that include quantum mechanics but not gravity. This is known as a dual and has fewer dimensions than its gravitational counterpart. The researchers used a quantum computer to create a hologram whose dual is a wormhole.



Quantum computing concept

Einstein's view of blackholes

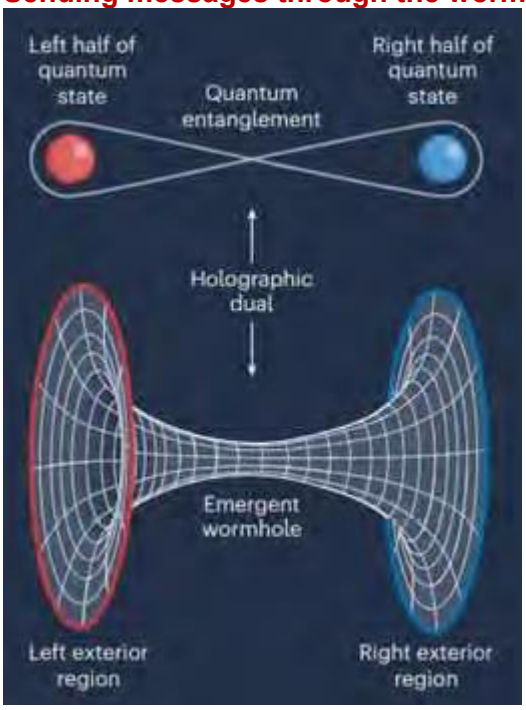
To understand the significance of this research, we need to go back to Einstein's research on black holes in the context of general relativity. With his collaborator, Nathan Rosen, Einstein said that a black hole had an interior region from where nothing could escape as well as an exterior region, from which escape was still possible.

The demarcation between the two was called the event horizon. What Einstein and Rosen realized was that a black hole had not just one but two exterior regions which were connected by a kind of wormhole which is now known as the **Einstein-Rosen bridge.** However, Einstein did not think that one could travel from one exterior region to another through the wormhole. Still, if one goes from one external region and crosses the event horizon, it is still feasible to interact (even if very briefly!) with someone who jumped from the other exterior region before meeting their death.

Einstein's work in quantum mechanics also speaks of quantum entanglement where objects in quantum systems are linked in a non-classical pattern, even though they are separated by long distances. Back in Einstein's time, the concepts of wormholes and quantum entanglement were considered separate, and the latter could not be used to send messages. Research over the years now points towards the two exteriors of the black hole being connected by quantum entanglement and the inability to travel from one exterior to another is considered to be the holographic dual of using quantum entanglement to send messages.

Researchers now posit that if the two exteriors of the black hole could be made to interact, it could also be used to send a message between them. This happens because during the interaction of the exteriors the wormhole opens up and becomes briefly traversable. To demonstrate this, one could use two halves of a quantum computer in an entangled state such that they are the holographic dual of blackhole exteriors connected by a wormhole and sending a message across.

Sending messages through the wormhole



An emergent wormhole in a quantum computer Springer Nature

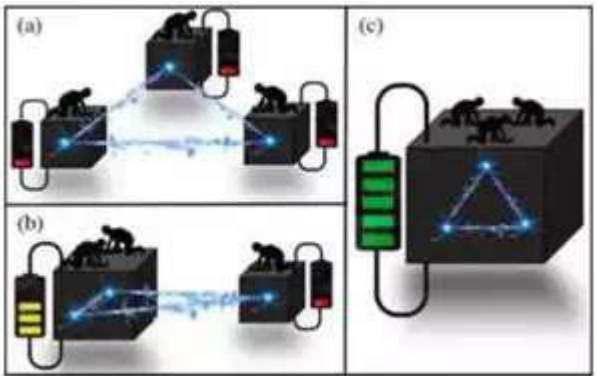
The research team led by Maria Spiropulu at the California Institute of Technology performed this simulation of a quantum system comprising of nine quantum bits (qubits) and saw that the message they sent through one half appeared at the other unscrambled. Since the quantum system used in the experiment is rather small, it does not teach us anything that we do not know or compute something that is not possible with the computation power at our disposal these days. Nevertheless, it sets the stage for future work in this direction and would help us test theories of quantum gravity, where both general relativity and quantum mechanics can be studied together.The research findings were published in the journal Nature today.

Source website links:

https://interestingengineering.com/science/holographic-wormhole-quantum-computer

Indian Scientists Devise New Concept in Same Field in which Physics Nobel Awarded

09 October, 2022 | by Surendra Singh



Indian scientists have devised a new theoretical concept in the field of _quantum information science and entangled photons' for which Alain Aspect, John F Clauser and Anton Zeilinger bagged the Nobel Prize in physics this year. The Indian scientists' findings could facilitate harnessing quantum entanglement for futuristic energy storage technology.

Quantum information science (QIS) is the study of applying quantum mechanics to computing, communication, sensing, and simulation. _Entangled photons' are two photons that are created together in such a way that their properties are correlated. This means that if a property of one photon changes (e.g., by collapsing into an atom), the other one must change too, no matter how far apart they are.

The Indian scientists have theorised a concept called _ergotropy' that represents the amount of extractable work from a system by keeping its entropy (measure of randomness of a system) constant.

The idea, if harnessed, can open pathways for putting quantum batteries to use in a way that is much more efficient than its classical counterpart. They have proposed thermodynamic quantities that capture a signature in multipartite quantum systems called _genuine multipartite entanglement' where several particles behave like a single unit even when they are separated.

Dr Manik Banik, scientist at S N Bose National Centre for Basic Sciences, an autonomous research institute under the department of science and technology, along with his colleagues Mir Alimuddin, a Chanakya post-doctoral fellow, and

Samgeeth Puliyil, a BSMS project student from Thiruvananthapuram-based Indian Institute of Science Education and Research, have turned their attention to genuine multipartite entangled systems that have more drastic manifestations. In their letter titled _Thermodynamicsignatures of genuinely multipartite entanglement‘ published in Physical Review Letters, they have highlighted that genuinely entangled states that are again of different types can be detected with the help of ergotropic gap. One can probe the individual parts locally to get useful energy which can further be stored in a battery for later uses. Probing can also be done on the whole composite system, resulting in extraction of more work. The difference between work extraction from individual parts and work extraction from the composite system is called ergotropic gap. Local thermality or local passivity of such states does not always imply that the global state is thermal or passive, and hence useful forms of energy can be extracted under global operations. From a composite quantum system ergotropic work therefore can be extracted by different means.

Source website links:

https://timesofindia.indiatimes.com/india/indian-scientists-devise-new-concept-in-same-field-in-which-physics-nobelawarded/ articleshow/94732047.cms?from=mdr

India's Mars Orbiter Mission is Finally Out of Fuel after 8 Years of Science Operations

11 October, 2022 | by Andy Tomaswick

Scientists and engineers seem to have difficulty coming up with estimated mission timelines for their space exploration projects. Most don‘t even reach the first day after succumbing to one form or another of technical failure, sometimes resulting in a dramatic fireball. Others have missions that extend orders of magnitude longer than they were originally designed for. Such is the case for India‘s first mission to the Red Planet, which finally seems to have run out of fuel eight years into its original six-month mission.

The mission, known colloquially as the Mars Orbiter Mission, or MOM, was initially launched in 2013 and entered an orbit around Mars in 2014. While in

orbit, it spent the better part of eight years collecting data to send back to its operating scientists at the Indian Space Research Organization (ISRO).

Though technically planned as a technology demonstrator, MOM, also known as Mangalyaan (or —Mars craft in Sanskrit), carried five scientific instruments, which, while they were relatively small and inexpensive, weighing in at just over 15 kg for the whole payload, they also provided critical insight into areas that scientists didn‘t understand about Mars at the time.

Watch video at: https://youtu.be/x4ZkrtuvZrI

One of those critical areas was **methane** – there was a longstanding debate about the sources of methane in Mars‘ atmosphere, and MOM helped to provide some insight into that. It acted as an excellent complement to other, more advanced, and

therefore more expensive, western orbiter efforts such as Maven, which was launched around the same time. But all good things must come to an end, and that was no exception for MOM. The spacecraft was designed to withstand many of the challenges associated with orbiting around the Red Planet, including using a limited supply of fuel to dodge out of the way of eclipses so that its batteries wouldn‘t be too diminished before being recharged by its on-board solar panels.

However, the fuel it used for maneuvering eventually ran out, and it was unable to dodge out of the way of an eclipse that lasted more than seven hours. Its batteries were designed to withstand an eclipse that lasted less than two hours. So when the craft finally emerged from the eclipse, its batteries were below the critical threshold that would allow it to restart. ISRO eventually declared the craft as officially decommissioned on October 3rd.

It leaves a generally positive legacy, though. India was one of the first countries to successfully introduce a craft to the Mars system on its first try. America and the Soviet Union suffered plenty of setbacks before the current round of successful rovers (and helicopters) traversing the planet.

That being said, the next step for ISRO in its Mars exploration program remains unclear. While the organization solicited ideas for a follow-up mission to Mars in 2016, no discernible progress has come through on that front in the last six years.

Despite that stagnation, ISRO should be proud of the work they already put in on MOM and of the scientific data that it collected. The more countries that can interact with Mars in one way or another, the better.

Source website links:

https://www.universetoday.com/158026/indias-mars-orbiter-mission-is-finally-out-of-fuel-after-8-years-of-scienceoperations/

Union Minister Dr Jitendra Singh says, Science has Turned Yesterday's Fairy Tales into Today's Reality and Therefore Optimum Mix of Traditional Knowledge with Modern Research can Result in Outcomes Beyond Imagination

05 November, 2022 | by PIB Delhi

Source website links: https://pib.gov.in/PressReleasePage.aspx?PRID=1873959

Says, visibility and global profile of the Indian space program scaled new heights under Modi Government. The Minister delivers the key-note address at the National Conference on Akash Tattva- "Akash for Life"at Uttaranchal University Campus, Dehradun. Dr Jitendra Singh says, Gaganyaan, the country"s first human space mission in 2024 will be a major milestone in India"s Space Odyssey

Union Minister of State (Independent Charge) Science & Technology; Minister of State (Independent Charge) Earth Sciences; MoS PMO, Personnel, Public Grievances, Pensions, Atomic Energy and Space, Dr Jitendra Singh today said that Science has turned yesterday's fairy tales into today's reality and therefore optimum mix of traditional knowledge with modern research can result in outcomes beyond imagination.

The Minister recalled that when he was a child, there was only radio and nobody had heard of a television but his teacher used to wishfully say that one day we

might be able to see the face of the news-reader on the radio. Similarly, when Sarabhai started the Space programme, most of us in India sang nursery rhymes about the moon without ever imagining that one day Indian missions will land on the surface of the moon, he added. Delivering the key-note address at the 4-day National Conference on Akash Tattva- ―Akash for Life‖at Uttaranchal University Campus in Dehradun, Dr Jitendra Singh said, Prime Minister Narendra Modi has enabled India to earn universal recognition for India's science, technology, innovation capabilities and our StartUps are much sought after. The whole world is looking at India as an inspirational place, as it is helping budding countries in capacity building and satellite building including nanosatellites, he said. The Minister said, all this has become possible due to constant
support and encouragement of Prime Minister Modi for scientific pursuits in all aspects of life during the last over eight years. He also underlined that it will be Science, Technology and Innovations that will define India‘s role in the next 25 years to make it a frontline scientific power in the world.

Veteran RSS Ideologue Bhaiyyaji Joshi, Chief Minister of Uttarakhand, Pushkar Singh Dhami, Jitender Joshi, Chancellor of Uttaranchal University, Principal Scientific Advisor to the Government of India, Prof Ajay Kumar Sood, Chairman ISRO, S. Somanath, Secretary Science & Technology, Dr S. Chandrasekhar, Secretary, Biotechnology, Dr Rajesh S Gokhale and Professors, Lecturers and Students joined the inaugural event.

Dr Jitendra Singh said, India‘s ascent to the world comity of Nations has begun and it will happen via Space Technology. He said, applications of Space Technology to different sectors like Railways, Highways, Agriculture, and Smart Cities brought _ease of living‘ for common man. He said, after the historic decision of the unlocking of the Space Sector in June, 2020, everyone is witnessing a transformation in the sector by bringing in start-ups, incubating them in space

technology and bringing great applications to develop rockets and satellites. More than 102 start-ups are working

in Space sector today. Moreover, Geospatial guidelines have enabled schemes like SVAMITVA to survey all the over 6 lakh Indian villages, the Minister added.

Dr Jitendra Singh said, though India‘s space aspirations are reflected in its missions to the Moon and Mars, the Gaganyaan, the country‘s first human space mission will be a major milestone in India‘s Space Odyssey. The Minister informed that unmanned Gaganyaan flight is scheduled by end 2023. Second unmanned flight will be by mid-2024 and the manned mission is planned by 2024.

Dwelling on the theme of Akash Tattva conclave, Dr Jitendra Singh said, this is a first of its kind event organized in India since Independence, where ancient wisdom is combined with Modern Research by striking an optimum balance to achieve the desired outcomes. The Minister lauded Bhaiyyaji Joshi for the brain behind Panchamahabhoot conclave on Aakash, Vaayu Jal, Prithvi and Agni. Giving the example of the opening up of the Traditional Knowledge Digital Library (TKDL) database to users, besides patent offices in August this year as a new dawn for Indian traditional knowledge, Dr Jitendra Singh said, it will be linked with modern knowledge and provide value addition to common users. He said, it also underlines the fact that without getting swayed by the fanciful stories or romanticism of the past or the ancient times, how best one can extract what is

relevant to modern times and this the crux of the Panchamahabhhoot-combining ancient wisdom with modern science.

Dr Jitendra Singh said, he is looking forward to new thoughts on various dimensions of Akash Tattva during the Dehradun Conclave as about 35 eminent speakers will share their perspectives in the three-day conclave. The Minister said, the main aim of the conclave is to expose the youth of India to the wisdoms of ancient science along with modern scientific advancements.

ISRO and all major scientific ministries and departments are joining hands with Vijnana Bharati to organize this National conference. Vijnana Bharati is a dynamic Science Movement with a Swadeshi Spirit, interlinking traditional and modern sciences on the one hand, and natural and spiritual sciences on the other hand.

The campaign _Sumangalam‘ is being organised across the country for finding the solutions to the environmental problems like global warming and climate with an Indian perspective. From the point of view of Indian traditional knowledge systems, five national conventions will be held across the country on the Panchmahabhoot - the five elements for solving environmental issues for the betterment of society. We all are aware that anchamahabhoota‘s consist of Aakash, Vaayu Jal, Prithvi and Agni.

ISRO Successfully Tests Cryogenic Engine that will Power India's Most Powerful Rocket

10 November, 2022 | by India Today Web Desk; Edited By: Sibu Kumar Tripathi

Source website links:
https://www.indiatoday.in/science/story/isro-lvm-3-launch-oneweb-satellite-cryogenic-engine-test-2295553-2022-11-10

The objective behind the hot fire test was to validate that the engine could carry a payload of up to 450 kilograms to space.

In Short The CE20 cryogenic engine was tested on Wednesday The Indian space agency had recently launched the LVM-3 on a mission The test enhanced the LVM3 payload capability up to 450 kg

The Indian Space Research Organisation (ISRO) has successfully tested the indigenously developed cryogenic engine that will power its heaviest rocket, the LVM-3. The Launch Vehicle Mark-III went through the hot test at an uprated thrust level of 21.8 tonnes for the first time.

ISRO said that the objective behind the hot fire was to test that the engine can support a payload capability of up to 450 kg with additional propellant loading. "This will enhance the LVM3 payload capability up to 450 kg with additional propellant loading," ISRO" said in a release following the burn.

The CE20 cryogenic engine that was tested on Wednesday has gone through major modifications compared to previous engines with Thrust Control Valve (TCV) for thrust control being introduced in the system. Isro said that in addition to it, 3D-printed LOX and LH2 turbine exhaust casings were inducted into the engine for the first time.

"During this test, the engine operated with 20 tonne thrust level for the first 40s, then the thrust level was increased to 21.8 tonnes by moving the thrust control

valve. During the test, engine and facility performance was normal and the required parameters were achieved," ISRO" said

The Indian space agency had recently launched the LVM-3 on a mission to deploy 36 satellites into Low Earth Orbit as part of a contract between OneWeb and InSPACE.One Web had signed a deal worth more than Rs 1000 crore for the launch and another GSLV launch carrying OneWeb payload is expected to launch in January of 2023.

The satellite constellation was launched onboard the Launch Vehicle Mark-III, which is a redesignated version of the Geosynchronous Launch Vehicle (GSLV Mk-III), from the Satish Dhawan Space Centre in Sriharikota. It was the first commercial launch for LVM-3. The satellites are a part of the 468 satellite constellation of OneWeb released into Leo Earth Orbit to provide Internet access to areas that are impossible to provide.

OneWeb had signed a deal worth more than Rs 1000 crore for the launch of its satellite constellation. (Photo: Isro)

The Fountain of Life: Scientists Uncover the “Chemistry Behind the Origin of Life”

https://scitechdaily.com/the-fountain-of-life-scientists-uncover-the-chemistry-behind-the-origin-of-life/

Chemists discover a mechanism for peptide-forming reactions to occur in water, which leads to proteins and so to life on Earth. It could also lead to the faster development of drugs to treat humanity’s most debilitating diseases.

Water Droplets Hold the Secret Ingredient for Building Life

Chemists uncover key to early Earth chemistry, which could unlock paths to speed up chemical synthesis for drug discovery. Purdue University chemists have discovered a mechanism for peptide-forming reactions to occur in water — something that has baffled scientists for decades.

“This is essentially the chemistry behind the origin of life,” said Graham Cooks. He is the Henry Bohn Hass Distinguished Professor of Analytical Chemistry in

Purdue's College of Science. "This is the first demonstration that primordial molecules, simple amino acids, spontaneously form peptides, the building blocks of life, in droplets of pure water. This is a dramatic discovery." Water Droplets Hold the Secret Ingredient for Building Life. Chemists uncover key to early Earth chemistry, which could unlock paths to speed up chemical synthesis for drug discovery. Purdue University chemists have discovered a mechanism for peptide-forming reactions to occur in water — something that has baffled scientists for decades.

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Cooks, an expert in mass spectrometry and early Earth chemistry, and his research team have uncovered the answer to the riddle: "Water isn't wet everywhere." On the margins, where the water droplet meets the atmosphere, extremely quick reactions can take place, transforming abiotic amino acids into the building blocks of life. Therefore, fertile landscapes for life's potential evolution were in places where sea spray flies into the air and waves pound the land, or where fresh water burbles down a slope. "This is the first demonstration that primordial molecules, simple amino acids, spontaneously form peptides, the building blocks of life, in droplets of pure water. This is a dramatic discovery." — Graham Cooks

The chemists have been using mass spectrometers to examine chemical reactions in droplets containing water for more than 10 years. "The rates of reactions in droplets are anywhere from a hundred to a million times faster than the same chemicals reacting in bulk solution," Cooks said.

The swift rates of these reactions make catalysts unnecessary, speeding up the reactions and, in the case of early Earth chemistry, making the evolution of life possible. Decades of scientific investigation have been focused on figuring out how this mechanism works. The secret of how life emerged on Earth can help scientists better understand why it happened and guide their search for life on other planets, or even moons.

Understanding how amino acids built themselves up into proteins and, eventually, life forms revolutionizes scientists' understanding of chemical synthesis. That same chemistry may potentially help synthetic chemists identify and create novel medications and therapeutic treatments for illnesses by accelerating key processes. "If you walk through an academic campus at night, the buildings with the lights on are where synthetic chemists are working," Cooks said. "Their experiments are so slow that they run for days or weeks at a time. This isn't necessary, and using droplet chemistry, we have built an apparatus, which is being used at Purdue now, to speed up the synthesis of novel chemicals and potential new drugs.

Shocking Experiment Indicates Our Brains Use Quantum Computation

https://scitechdaily.com/shocking-experiment-indicates-our-brains-use-quantum-computation/

The results of an experiment to explore the human brain and its workings, which was adapted from an idea developed to prove the existence of quantum gravity, indicate that our brains use quantum computation.

Scientists believe our brains could use quantum computation after taking a concept developed to prove the existence of quantum gravity and adapting it to explore the human brain and its workings. The discovery may shed light on consciousness, the workings of which remain scientifically difficult to understand and explain. *Quantum brain processes could also explain why humans can still outperform supercomputers when it comes to unforeseen circumstances, decision-making, or learning something new*. After adapting an idea developed to prove the existence of quantum gravity to explore the human brain and its workings, researchers from Trinity College Dublin think that human brains could use quantum computation.

The brain functions measured in the experiment were also correlated to short-term memory performance and conscious awareness. This suggests that quantum processes are also part of cognitive and conscious brain functions.

"If entanglement is the only possible explanation here then that would mean that brain processes must have interacted with the nuclear spins, mediating the entanglement between the nuclear spins. As a result, we can deduce that those brain functions must be quantum.." — Dr. Christian Kerskens

If the team's results can be corroborated, which would likely require advanced multidisciplinary approaches, they would improve our general understanding of how the brain works. The insights could potentially reveal how the brain can be maintained or even healed. They may also help uncover innovative technologies and build even more advanced quantum computers.

Dr. Christian Kerskens is the co-author of the research article that was published on October 7 in the Journal of Physics Communications. He is also lead physicist at the Trinity College Institute of Neuroscience (TCIN), He said:

We adapted an idea, developed for experiments to prove the existence of quantum gravity, whereby you take known quantum systems, which interact with an unknown system. If the known systems entangle, then the unknown must be a quantum system, too. It circumvents the difficulties to find measuring devices for something we know nothing about.

"For our experiments, we used proton spins of 'brain water' as the known system. 'Brain water' builds up naturally as fluid in our brains and the proton spins can be measured using MRI (Magnetic Resonance Imaging). Then, by using a specific MRI design to seek entangled spins, we found MRI signals that resemble heartbeat-evoked potentials, a form of EEG signals. EEGs measure electrical brain currents, which some people may recognize from personal experience or simply from watching hospital dramas on TV."

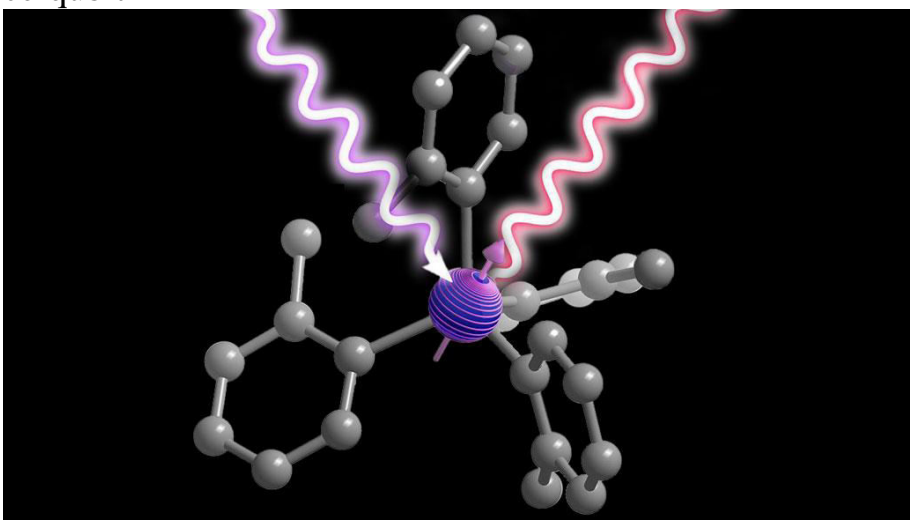
Electrophysiological potentials like the heartbeat-evoked potentials are normally not detectable with MRI and the scientists believe they could only observe them because the nuclear proton spins in the brain were entangled.

Dr. Kerskens added:

“If entanglement is the only possible explanation here then that would mean that brain processes must have interacted with the nuclear spins, mediating the entanglement between the nuclear spins. As a result, we can deduce that those brain functions must be quantum. “Because these brain functions were also correlated to short-term memory performance and conscious awareness, it is likely that those quantum processes are an important part of our cognitive and conscious brain functions. “Quantum brain processes could explain why we can still outperform supercomputers when it comes to unforeseen circumstances, decision making, or learning something new. Our experiments performed only 50 meters away from the lecture theater, where Schrödinger presented his famous thoughts about life, may shed light on the mysteries of biology, and on consciousness which scientifically is even harder to grasp.”

Designer Molecules' could Create Tailor-made Quantum Devices

Researchers are concocting molecules specially suited for use as quantum bits or sensors Source ::https://www.sciencenews.org/article/chemistry-designer-molecules-quantum-device-qubit



A molecule with a central chromium ion (purple) can serve as a quantum bit, encoding information in the direction of its spin (indicated by its arrow in this illustration). Attached atoms (gray) alter the properties of the ion, allowing it to be manipulated by a laser (purple squiggle) and to emit light in response (red squiggle). Daniel Laorenza/Northwestern University Quantum bits made from "designer molecules" are coming into fashion. By carefully tailoring the composition of molecules, researchers are creating chemical systems suited to a variety of quantum tasks. "The ability to control molecules … makes them just a beautiful and wonderful system to work with," said Danna Freedman, a chemist at Northwestern University in Evanston, Ill. "Molecules are the best." Freedman described her research February 8 at the annual meeting of the American Association for the Advancement of Science, held online. Quantum bits, or qubits,

are analogous to the bits found in conventional computers. But rather than existing in a state of either 0 or 1, as standard bits do, qubits can possess both values simultaneously, enabling new types of calculations impossible for conventional computers.

Besides their potential use in quantum computers, molecules can also serve as quantum sensors, devices that can make extremely sensitive measurements, such as sussing out minuscule electromagnetic forces (SN: 3/23/18). In Freedman and colleagues' qubits, a single chromium ion, an electrically charged atom, sits at the center of the molecule. The qubit's value is represented by that chromium ion's electronic spin, a measure of the angular momentum of its electrons. Additional groups of atoms are attached to the chromium; by swapping out some of the atoms in those groups, the researchers can change the qubit's properties to alter how it functions. Recently, Freedman and colleagues crafted molecules to fit one particular need: molecular qubits that respond to light. Lasers can set the values of the qubits and help read out the results of calculations, the researchers reported in the Dec. 11 Science. Another possibility might be to create molecules that are biocompatible, Freedman says, so they can be used for sensing conditions inside living tissue.

Molecules have another special appeal: All of a given type are exactly the same. Many types of qubits are made from bits of metal or other material deposited on a surface, resulting in slight differences between qubits on an atomic level. But using chemical techniques to build up molecules atom by atom means the qubits are identical, making for better-performing devices. "That's something really powerful about the bottom-up approach that chemistry affords," said Freedman. Scientists are already using individual atoms and ions in quantum devices (SN: 6/29/17), but molecules are more complicated to work with, thanks to their multiple constituents. As a result, molecules are a relatively new quantum resource, Caltech physicist

Nick Hutzler said at the meeting. “People don’t even really know what you can do with [molecules] yet.… But people are discovering new things every day.”

World's First Optical Atomic Clock with Highly Charged Ions

02 November, 2022 | by Physikalisch-Technische Bundesanstalt

Highly charged ions are a common form of matter in the cosmos,where they are found, for example, in the sun or other stars. They are so called because they have lost many electrons and therefore have a high positive charge. This is why the outermost electrons are more strongly bound to the atomic nucleus than in neutral or weakly charged atoms.

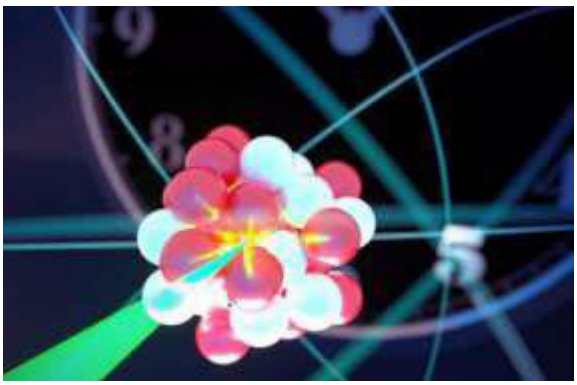


Illustration of the laser interrogation of a highly charged ion clock (artwork). Credit: PTB

For this reason, highly charged ions react less strongly to interference from external electromagnetic fields, but become more sensitive probes of fundamental effects of special relativity, quantum electrodynamics and the atomic nucleus. "Therefore, we expected that an optical atomic clock with highly charged ions would help us to better test these fundamental theories", explains PTB physicist Lukas Spieß. This hope has already been fulfilled: "We were able to detect the quantum electrodynamic nuclear recoil, an important theoretical prediction, in a

five-electron system, which has not been achieved in any other experiment before." Beforehand, the team had to solve some fundamental problems, such as detection and cooling, in years of work: For atomic clocks, one has to cool the particles down extremely in order to stop them as much as possible and thus read out their frequency at rest. Highly charged ions, however, are produced by creating an extremely hot plasma.

Because of their extreme atomic structure, highly charged ions can't be cooled directly with laser light, and standard detection methods can't be used either. This was solved by a collaboration between MPIK in Heidelberg and the QUEST Institute at PTB by isolating a single highly charged argon ion from a hot plasma and storing it in an ion trap together with a singly charged beryllium ion. This allows the highly charged ion to be cooled indirectly and studied by means of the beryllium ion. An advanced cryogenic trap system was then built at MPIK and finalized at PTB for the following experiments, which were carried out in part by students switching between the institutions. Subsequently, a quantum algorithm developed at PTB succeeded in cooling the highly charged ion even further, namely close to the quantum mechanical ground state. This corresponded to a temperature of 200 millionths of a Kelvin above absolute zero. These results were already published in Nature in 2020 and in Physical Review X in 2021. Now the researchers have successfully taken the next step: They have realized an optical atomic clock based on thirteen-fold charged argon ions and compared the ticking with the existing ytterbium ion clock at PTB. To do this, they had to analyze the system in great detail in order to understand, for example, the movement of the highly charged ion and the effects of external interference fields. They achieved a measurement uncertainty of 2parts in 1017—comparable to many currently operated optical atomic clocks. "We expect a further reduction of the uncertainty

through technical improvements, which should bring us into the range of the best atomic clocks," says research group leader Piet Schmidt.

The researchers have thus created a serious competitor to existing optical atomic clocks based on, for example, individual ytterbium ions or neutral strontium atoms. The methods used are universally applicable and allow many different highly charged ions to be studied. These include atomic systems that can be used to search for extensions of the Standard Model of particle physics. Other highly charged ions are particularly sensitive to changes in the fine structure constant and to certain dark matter candidates that are required in models beyond the Standard Model but could not be detected with previous methods.

Source website links:

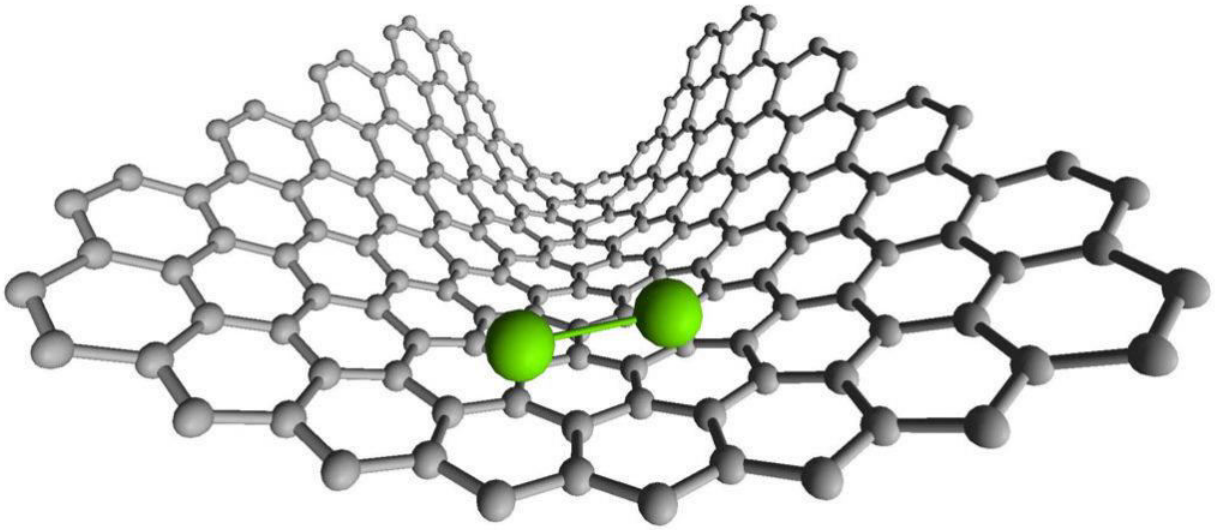
https://phys.org/news/2022-11-world-optical-atomic-clock-highly.html

A dance of two atoms reveals chemical bonds forming and breaking

Source:

https://www.sciencenews.org/article/dance-two-atoms-reveals-chemical-bonds-forming-breaking

Two rhenium atoms approach and retreat from one another in an electron microscope video



Scientists have now captured video of the intimate dance of two atoms as they bond with one another, break apart and come back together again. In a sequence of images from an electron microscope, two atoms of the metal rhenium, bound together to create a molecule, shimmied around one another, moving closer and then farther apart. In videos of such molecules, this atomic do-si-do revealed the bond order, or the number of chemical bonds between the two atoms, and how that bond order changed over time. The closer the atoms were to one another, the greater the number of bonds. At their closest approach, the atoms had four bonds tethering them together. To make imaging easier, scientists trapped the molecules inside carbon nanotubes. But then, in a fortuitous accident, one molecule escaped its confinement and nestled into a gap between two nanotubes. There, the bond

between the atoms completely broke before soon reforming, the team reports January 17 in Science Advances.

Researchers had previously coaxed two atoms to bond (SN: 4/12/18). But directly observing how chemical bonds change in number “was not done before,” says physicist Ute Kaiser of Ulm University in Germany. Kaiser and colleagues made the images with a transmission electron microscope specially designed to operate at low voltages, so that its beam of electrons wouldn’t damage the carbon nanotubes or send the rhenium atoms flying. That electron beam was useful for imaging, but also served another purpose: It gently jostled the atoms, causing them to dance rather than sitting still.

Here are the Top 10 science anniversaries of 2022

https://www.sciencenews.org/article/top-10-science-anniversaries-2022

Insulin to treat diabetes, the slide rule and the birthdays of Gregor Mendel and Louis Pasteur make the list

Even though it's only even odds that 2022 will turn out to be less of a disaster than 2021 (or 2020), at least 2022 is the best recent year for compiling a Top 10 list of science anniversaries.

Curiously, many of those anniversaries are of deaths: the astronomer William Herschel for instance, who died in 1822; Hermann Rorschach, Alexander Graham Bell and the mathematician Sophie Bryant (all in 1922); and Louis Leakey (1972).

But there are also some notable firsts (the original slide rule, for instance) and births, including the scientist who illuminated how science could save society from devastating infectious diseases. Honorable mentions go to the birthdays of physicists Rudolf Clausius (200th), Leon Lederman (100th) and C.N. Yang (100th). They just missed edging out the oldest anniversary, a death from an earlier millennium:

10. Al-Nayrīzī, 1,100th anniversary of death

Abū'l-'Abbās al-Faḍl ibn Ḥātim al-Nayrīzī was a Persian mathematician and astronomer, probably born around A.D. 865 in the town of Nayriz (in present-day Iran), which is why he became known as al-Nayrīzī. He died in 922 or thereabouts (close enough for Top 10 purposes). He got a job in Baghdad with the caliph al-Mu'taḍid, writing treatises on math and weather, among other topics.

Unfortunately, many of al-Nayrīzī's writings were long ago lost. But other writers mention his works and report that he was a master of astronomy and geometry. Among his surviving works is a translation and commentary on Euclid's Elements.

Al-Nayrīzī also attempted a proof of Euclid's famous postulate about parallel lines never meeting. One of Al-Nayrīzī's treatises for the caliph discussed how to determine the distance to upright objects. Had golf been invented yet, the caliph would have used such knowledge to calculate the distance to the flagstick without need of a GPS app.

9. Invention of mathematical weather forecasting, 100th anniversary

Lewis Fry Richardson, a mathematician who later turned to psychology, worked early in his career at England's National Peat Industries. He was given the task of calculating optimal designs of drainage systems for peat moss subjected to different amounts of rain. He worked out the equations and then realized they could be applied to other problems, such as predicting the weather.

In the years leading up to World War I, he worked on a book, to be titled Weather Prediction by Numerical Process. He showed how values for temperature, humidity, air pressure and other weather data from one day could be processed by his equations to make a forecast for the next day. He took a break to be an ambulance driver during the war and then finished his book, published in 1922.

As Science News-Letter reported that year, one U.S. Weather Bureau scientist believed the book to show "that meteorology has become an exact science." Unfortunately, to make the next day's forecast from one day's data took Richardson six weeks of calculation time. Only decades later did modern electronic computers make the mathematics of weather forecasting practical, and sometimes useful.

8. Invention of slide rule, 400th anniversary

William Oughtred, born in England in 1575, became a priest and part-time mathematician and tutor. In 1631 he wrote a book summarizing arithmetic and

algebra, which became widely popular, later earning lavish praise from Isaac Newton.

Nine years before his book, Oughtred had designed the first slide rule. In 1614 John Napier had invented logarithms, showing how multiplication could be accomplished by addition. Six years later the astronomer Edmund Gunter had the bright idea of marking numbers on a straightedge proportional to their logarithms. Multiplication could then be performed by using a compass (the caliper kind, not for finding north) to find the answer by measuring the distances between the numbers to be multiplied.

In 1622, Oughtred had the even brighter idea of placing two such rulers next to each other. Sliding one along the other to properly position the numbers of interest allowed him to read the product of a multiplication right off one of the rulers. Oughtred later designed a circular slide rule, but one of his students claimed to have had that idea first, initiating a nasty priority dispute.

Further advances in slide rule design, incorporating things like cubes and trigonometric functions, made slide rules the premier computing devices of the 19th and 20th centuries — UNTIL electronic calculators came along, sadly depriving slide rules the opportunity to make it to age 400. But some people alive today once used slide rules, and probably still have one in a box somewhere.

7. Maria Goeppert Mayer, 50th anniversary of death

Maria Goeppert was born in what is now Poland in 1906. Encouraged by her father, a university professor, to pursue higher education, Maria chose mathematics. But in the mid-1920s her fascination with a newfangled idea called quantum mechanics induced her to shift to physics. After earning her Ph.D., she married a chemist (Joseph Mayer) and moved to the United States. She was allowed to teach classes where her husband was on the faculty (first at Johns Hopkins, later at Columbia and then Chicago) but not offered a job of her own. She

was free to pursue research projects, though, often in collaboration with her husband or other scientists, and she produced important work on many topics at the interface of quantum physics and chemistry.

She was a master of the math needed to understand spectroscopy; her studies of the light emitted by the newly discovered transuranic elements in the 1940s showed that they belonged in a chemical family related to the rare-earth elements — an essential clue to the proper positioning of the transuranics in the periodic table. After World War II, she began studying nuclear physics and soon deduced the existence of a shell-like structure for the arrangement of nucleons (protons and neutrons) in the atomic nucleus. Her findings complemented similar work by Hans Jensen, with whom she later collaborated in writing a book on the nuclear shell model. Jensen and Goeppert Mayer shared the 1963 Nobel in physics for that work.

Her shell model research was aided by a suggestion from Enrico Fermi, the physicist famous for his work on the secret Manhattan Project to build the atomic bomb. That was only fair, as when Fermi disappeared from Columbia University in 1941 to work on the bomb, Goeppert Mayer was hurriedly recruited to teach his class. In 1960, Goeppert Mayer finally was awarded a full-time primetime job of her own at the University of California, San Diego, but shortly thereafter she suffered a stroke, limiting her ability to do research in the years before her death in 1972.

Maria Goeppert Mayer, who died in 1972, received a Nobel Prize in physics for her work on the arrangement of protons and neutrons in the atomic nucleus.Everett Collection Historical/Alamy Stock Photo

6 . Aage Bohr, 100th birthday

Niels Bohr was awarded the Nobel Prize in physics in 1922, the same year as the birth of his son Aage. Aage grew up surrounded by physicists (who came from around the world to study with his father) and so naturally became a physicist himself. During World War II, Aage accompanied his father to the United States to work on the Manhattan Project, afterwards returning to his native Denmark to earn his Ph.D. at the University of Copenhagen. During that time Aage turned his attention to a problem with the atomic nucleus.

His father's theory that a nucleus behaves much like a drop of liquid had been applied successfully in explaining nuclear fission. But more recent work by Maria Goeppert Mayer (remember her?) showed that nuclei had an inner shell-like structure, suggesting ordered arrangements of individual particles, not collective,

liquidlike behavior. Aage developed a new theoretical view, showing that his father's view could be reconciled with Goeppert Mayer's shell model. He then worked on experiments that corroborated it and shared the 1975 physics Nobel "for the discovery of the connection between collective motion and particle motion in atomic nuclei and the development of the theory of the structure of the atomic nucleus based on this connection."

5. Gregor Mendel, 200th birthday

Born July 22, 1822 to a family of farmers in what is now the Czech Republic, Johann Mendel preferred higher education to farming, enrolling in a philosophy program properly complemented with math and physics. When the time came to return home and take charge of the family farm, he opted instead to enter a monastery (where he adopted the monastic name Gregor). He did not particularly enjoy his priestly duties, though, so he got a job as a teacher, which required him to enter the University of Vienna for advanced science education. There, in addition to more math and physics, he encountered botany. Later he returned to the monastery, where he applied his botanical skills to investigating patterns in the physical features of successive generations of pea plants.

In 1866 he published results implying the existence of "differentiating characters" (now known as genes) that combined in different ways when transmitted by parents to offspring. Apparently nobody very astute read his paper, not even Charles Darwin, who would have been intrigued by Mendel's mention that his work was relevant to "the history of the evolution of organic forms." Only at the dawn of the 20th century was Mendel's work translated into English and then recognized for its importance to heredity, evolution and biology in general.

4. Pioneer 10, 50th anniversary of launch

Of all the robotic spacecraft launched from Earth into space, Pioneer 10 was truly the pioneer. It was the first craft to fly beyond the orbit of Mars and the first to exceed the distance of the solar system's outermost planet, Neptune. Launched March 2, 1972, Pioneer 10's mission was to visit Jupiter to take some cool snapshots of the giant planet and a few of its moons. Pioneer's escape velocity from Earth surpassed 51,000 kilometers per hour (about 32,000 miles per hour), at the time a solar system speed record for any flying machine or bird. After dodging asteroids (most of them anyway) on its journey, Pioneer 10 reached the solar system's largest planet in late 1973, passing within 131,000 kilometers (about 81,000 miles) on December 4.

Pioneer continued transmitting signals back to Earth until 1997, when budget cuts forced NASA to stop listening except for an occasional check-in. The very last signal came on January 23, 2003, from 7.6 billion miles away. By now Pioneer 10

is roughly 12 billion miles away, headed in the direction of the star Aldebaran. It will arrive in a mere 2 million years or so. If any Aldebaranians encountering it can decipher the sketches of a man and woman and the map revealing the point of origin, perhaps they will refuel it and send it back.

3. Insulin treats diabetes, 100th anniversary

In a century of medical miracles, one of the earliest and most dramatic was the discovery of insulin for treating diabetes. Diabetes had been recognized as a serious disease in ancient times. By the 20th century, scientists suspected that the pancreas produced a substance that helped metabolize carbohydrates; a malfunctioning pancreas meant a person could not extract energy from carbohydrates in food, resulting in dangerously high blood sugar levels while depriving the body of needed energy. It was nearly always fatal in children, and adults diagnosed with diabetes could hope for only a few more years of life.

As Science News-Letter reported in 1922, diabetes ranked “with cancer in fatality and incurability.” But in that year, a young doctor reported success in treating diabetes with a substance secreted by the pancreas. That doctor, Frederick Banting, had tried the idea with dogs the year before and gave the first insulin injection to a human, a 14-year-old boy, in January 1922. Banting originally used insulin purified from animals; in the decades since, researchers have engineered more sophisticated forms for human use. But even with the animal insulin, success was so dramatic that Banting and his lab director John Macleod were awarded the Nobel Prize in physiology or medicine in 1923.

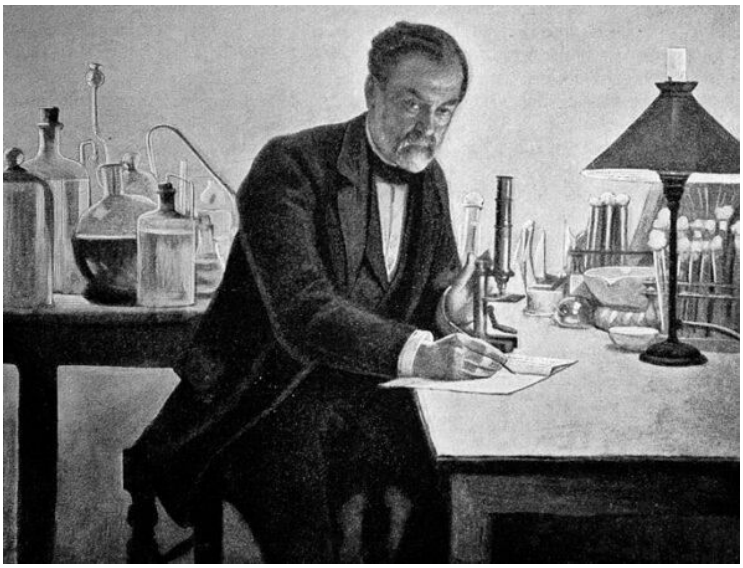
2. Science News, 100th birthday

In its first year of providing news of science to the world, the organization then known as Science Service transmitted a weekly package of mimeographed pages

(labeled Science News Bulletin) to newspapers and other media around the country. But soon other groups (such as libraries) as well as individuals began to request the package, and so Science Service initiated a new strategy with issue No. 50. On March 13, 1922, Science News-Letter was born, with a new masthead offering subscriptions for $5 per year, postpaid. Its first article: an account of a U.S. Department of Commerce report on the allocation of radio wavelengths. The report assured everybody that "widespread use of radio for the broadcasting of public information and other matters of general interest" would be forthcoming. In 1966 the magazine dropped "Letter" and became Science News, providing an excuse for another centennial celebration in 2066.

1. Louis Pasteur, 200th birthday

Born in France in December 1822, Louis Pasteur was not a precocious youth. His interests tended toward art, but later some inspiring lectures shifted his attention to chemistry, and he became one of the greatest chemists of all time. Also one of the greatest biologists. And although he received no medical education, he provided the foundation for modern medicine's ability to fight disease.



Louis Pasteur, born in 1822, has done more than any one person to preserve human health and prevent unnecessary deaths.Nastasic/DigitalVision Vectors/Getty Images Plus

Pasteur's understanding of microorganisms led to the recognition of their capacity to damage human health. His tenacity in conducting rigorous experiments and his pugnacious public promotion of his findings established the germ theory of disease and encouraged new methods of hygiene. Time after time he was called on to devise solutions for perplexing problems facing various industries. He saved the silk industry. He showed how to prevent wine from going sour, and how to make milk safe to drink. He devised vaccines for various diseases, including one to cure rabies. No one person in history is more responsible than Pasteur for preserving human health and preventing unnecessary deaths. He is lucky he was born 200 years ago, though. If he were around today, he'd be getting death threats.