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3 physicists share Nobel for work on quantum science

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NEW DELHI: Three scientists jointly won this year's Nobel Prize in physics on Tuesday for their work on quantum information science, a “totally crazy” field that has significant applications, including in the field of encryption.

Frenchman Alain Aspect, American John F Clauser and Austrian Anton Zeilinger were cited by the Royal Swedish Academy of Sciences for discovering the way that unseen particles, such as photons, can be linked or “entangled”, with each other even when they are separated by large distances, a field that unsettled Albert Einstein himself, who once referred to it in a letter as “spooky action at a distance”.

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Medicine Nobel goes to Neanderthal researcher Svante Paabo

What is Quantum Mechanics?

Classical physics tells us that two objects cannot occupy the same space at the same time. Until the early 20th century, it was believed that this was a fundamental law of physics followed by everything in nature. But then scientists began studying

particles like atoms, electrons and light waves, which did not appear to obey these laws. And so, the field of quantum mechanics was born, pioneered by Max Planck, Neils Bohr and Albert Einstein, in an attempt to investigate the “quirky” laws that did bind such particles.

Quantum mechanics, for instance, tells us light can be both a particle and a wave – depending on how it is observed. But until it is observed, light is neither a particle nor a wave. This lack of definition led Einstein to remark, “God does not play dice with the universe”. Since then, physicists have been investigating the laws that govern this uncertainty.

List of 10 most recent Nobel Physics Prize winners

2021	Syukuro Manabe (US-Japan), Klaus Hasselmann (Germany) and Giorgio Parisi (Italy) for groundbreaking contributions to our understanding of complex physical systems.
2020	Roger Penrose (Britain), Reinhard Genzel (Germany) and Andrea Ghez (US) for their research into black holes.
2019	James Peebles (Canada-US) for discoveries explaining the universe's evolution after the Big Bang, and Michel Mayor and Didier Queloz (Switzerland) for the first discovery of an exoplanet.
2018	Arthur Ashkin (US), Gerard Mourou (France) and Donna Strickland (Canada) for inventions in the laser field used for advanced precision instruments in corrective eye surgery and industry.
2017	Barry Barish, Kip Thorne and Rainer Weiss (US) for the discovery of gravitational waves, a phenomenon predicted by Albert Einstein a century ago as part of his theory of general relativity.
2016	David Thouless, Duncan Haldane and Michael Kosterlitz (Britain) for their study of strange phenomena in unusual phases, or states, of matter, such as superconductors, superfluids or thin magnetic films.
2015	Takaaki Kajita (Japan) and Arthur McDonald (Canada) for their work on neutrinos.
2014	Isamu Akasaki (Japan), Hiroshi Amano (Japan) and Shuji Nakamura (US) for their work on LED lamps.
2013	Peter Higgs (Britain) and Francois Englert (Belgium) for their work on the so-called Higgs boson, a subatomic particle that gives mass to other particles.
2012	Serge Haroche (France) and David Wineland (US) for experimental methods used to measure and manipulate quantum systems.

TOI Source: nobelprize.org

A leap forward for Quantum Mechanics

Quantum mechanics, unlike classical physics, allows two or more particles to exist in an entangled state – what happens to one particle in an entangled pair determines what happens to the other, even if the particles are at a great distance from each other. Physicists initially believed that this coordination was the result of hidden variables – Einstein described it as "spooky action at a distance".

But in the 1960s, John Stewart Bell found that there aren't any hidden variables at play – in fact, the coordination between entangled particles is a matter of chance when measuring the properties of one of the particles.

Bell developed a mathematical inequality that says, "if there are hidden variables, the correlation between the results of a large number of measurements will never exceed a certain value". However, quantum mechanics shows that it is possible to exceed this value, resulting in a greater correlation between the result than is possible through hidden variables.

How Nobel Prize has been awarded over the years

Between 1901 and 2020, the Nobel Prizes and the prize in economic sciences were awarded 609 times.

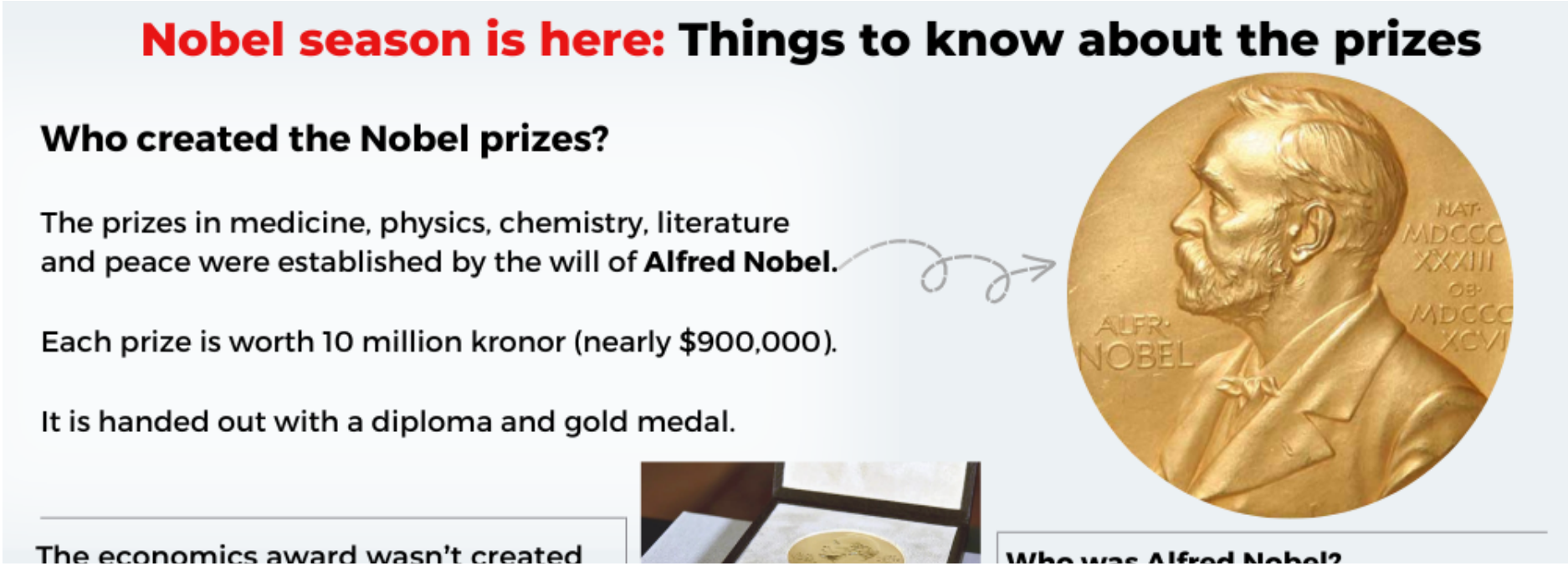
Nobel Prize	Number of prizes	Number of laureates	Awarded to one laureate	Shared by two laureates	Shared by three laureates
Physics	115	219	47	32	36
Chemistry	113	186	63	24	25
Medicine	112	224	39	34	39
Literature	114	118	110	4	-
Peace	103	109 + 28*	69	31	2
Economic sciences	53	89	25	20	8
Total:	609	975	353	146	110

TOI * 28 organizations have been awarded Nobel Peace prize • Source: nobelprize.org

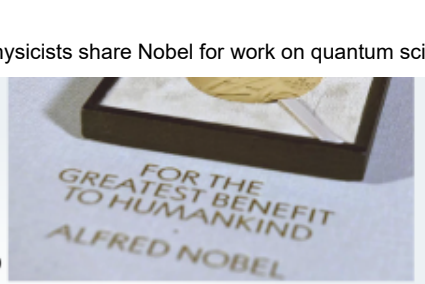
Exceeding this value proves that there is no unexplained “spooky action” and that the world is governed by quantum mechanics.

Over a span of several decades, this year’s Nobel laureates have built on Bell’s work. American physicist John Clauser developed a realistic experiment by passing entangled photons through polarisation filters (commonly used in sunglasses to block light at certain angles) to test Bell’s inequality. His experiments showed a clear violation of Bell’s inequality, confirming that there were no hidden variables at play.

But Clauser’s experiment had its limitations — the settings for measuring the entangled photons passing through the polarisation filters were fixed, meaning it was possible that the experimental setup itself may have been unable to detect some particles that were controlled by hidden variables. Alain Aspect, a French physicist at the Universite Paris-Saclay, sought to develop an experiment that removed this potential bias by changing the measurement settings only after the entangled photons left their source so that the setup itself would not impact the results.



by Nobel, but by Sweden's central bank in 1968.

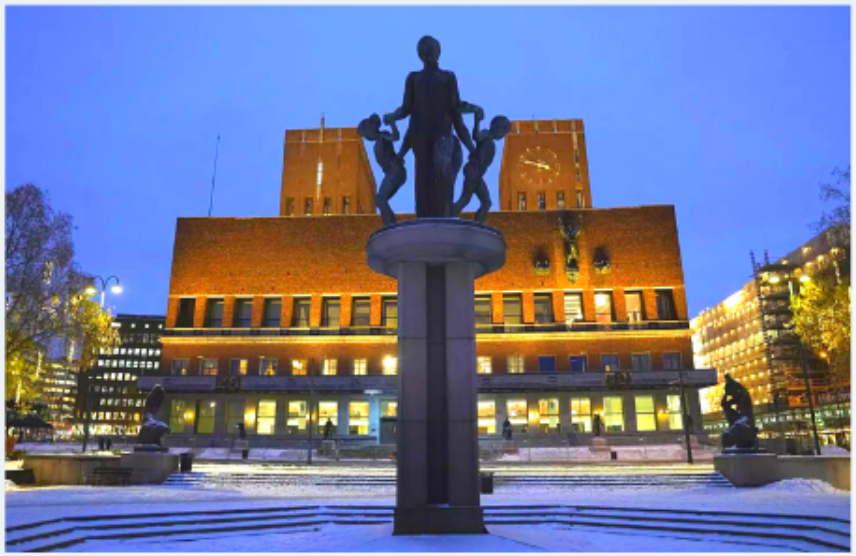


Who can nominate a candidate?

Thousands of people around the world are eligible to submit nominations for the Nobel Prizes.

They include university professors, lawmakers, previous Nobel laureates & committee members themselves.

The judges try hard to avoid dropping hints about the winners before the announcements, but sometimes word gets out.

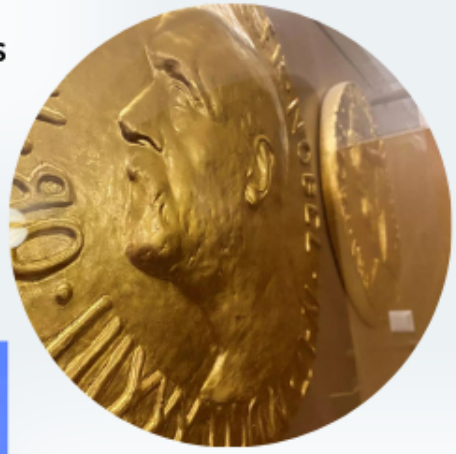


Who was Alfred Nobel?

He was a wealthy Swedish industrialist and inventor of dynamite.

He died in 1896.

First awards were handed out in 1901, 5 years after his death.



Although the nominations are kept secret for 50 years, those who submit them sometimes announce their suggestions publicly, particularly for the Nobel Peace Prize.

What about the Norwegian connection?

The Nobel Peace Prize is presented in Norway while the other awards are handed out in Sweden.

That's how Alfred Nobel wanted it.
His exact reasons are unclear.

What does it take to win a Nobel?

Patience, for one. Scientists often have to wait decades to have their work recognised by the Nobel judges.

The peace prize committee is the only one that regularly rewards achievements made in the previous year.

According to Nobel's wishes, that prize should go to "the person who shall have done the most or the best work for fraternity between nations".

Anton Zeilinger, an Austrian physicist at the University of Vienna, was among the first to explore quantum systems that use more than two entangled particles, which now form the basis of quantum computation and allow entangled particles to be manipulated. Among his most notable achievements is the discovery of quantum teleportation, which allows particles to take on even unknown quantum characteristics from other particles over long distances.

But what do these advances in quantum mechanics mean for the world? Transistors and lasers were developed as a result of the first quantum revolution.

In this new era, the ability to manage and manipulate systems of entangled particles will give researchers better tools to "construct quantum computers, improve measurements, build quantum networks and establish secure quantum encrypted communication". Quantum computers can perform complex calculations that are far beyond the capabilities of conventional computers, which rely on binary signals (1s and 0s) to store and process information. Already, quantum computing has shown promise in chemical and biological engineering and cybersecurity. Areas like artificial intelligence and Big Data also stand to benefit from computing systems that can handle large datasets and run complex simulations.