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Nobel Prize Winning Works in Chemistry and their Impact on Society

Dr. Chandra Prakash Gharu

Assistant Professor, Department of Chemistry, Government College, Barmer, Rajasthan, India

ABSTRACT

How different are the careers of Nobel laureates from other scientists? US research suggests they follow similar patterns up until the point they win the Nobel prize. Like 'ordinary' scientists they rely on collaborations, and have what the authors describe as 'hot streaks' – periods where an individual scientist's performance is substantially better than usual. However, the laureates were more productive, likely to have longer 'hot streaks' and more than one hot streak, compared with ordinary scientists. The authors were surprised to find a significant but temporary dip in the impact of the work of laureates in the first or second year following the prize, even though they were just as productive, and had similar amounts of funding available. The impact of their work was judged by the number of papers in the top 1% of citations, for the four years immediately before and after the award. The impact dip is most pronounced among physicists – with a drop of 18.1% in the second year after the award – but smallest in chemists – with a drop of 4.8%. There was also a significant decrease in individual work by both chemistry and medicine laureates after the prize. Dashun Wang, at the Centre for Science of Science and Innovation at Northwestern University, says they had expected to see evidence of the premium that comes with the prize – that increased visibility would increase the impact of their work. Wang and his colleagues investigated laureates' performance chemistry, physics, and physiology and medicine Nobel prize winner from 1900 to 2016. They also established a comparison data set of more 'ordinary' scientists – for each laureate who published their first paper after 1960, they randomly selected 20 scientists in the same discipline and who started their careers at the same time. But a deeper look at research topics suggests that, after being awarded the prize, laureates had a higher likelihood of switching topics than would be expected if they randomly changed research direction at any point in their career. One example is that of Jean-Marie Lehn, one of three scientists who were awarded the 1987 chemistry Nobel prize for the synthesis of crypt ands. Immediately after winning, Lehn's focus shifted to self-assembly and self-organisation – a topic he'd never previously published on. 'It's not clear why this happens the moment you win the prize,' especially as it's difficult to predict when that will be, says Wang. But it perhaps demonstrates 'the unwavering effort of Nobel laureates to keep pushing the frontier'. Alex Petersen, in the management of complex systems department at the University of California Merced, is also intrigued by the findings. 'Winning a Nobel prize affords you a lot of freedom to change research direction,' he says, and adds that perhaps the dip is 'just using a range of resources to create a database of nearly every showing the lag in time it takes the research community to decide whether or not a new direction is worth following'.

KEYWORDS: *nobel prize, chemistry, society, scientists, innovation, management, community*

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INTRODUCTION

The Nobel Prize in Chemistry (Swedish: Nobelpriset i kemi) is awarded annually by the Royal Swedish Academy of Sciences to scientists in the various fields of chemistry. It is one of the five Nobel Prizes established by the 1895 will of Alfred Nobel, who died in 1896. These prizes are awarded for outstanding contributions in chemistry, physics, literature, peace, and physiology or medicine.[1] As dictated by Nobel's will, the award is administered by the Nobel Foundation and awarded by the Royal Swedish Academy of Sciences.[2] The first Nobel Prize in Chemistry was awarded in 1901 to Jacobus

Henricus van 't Hoff, of the Netherlands. Each recipient receives a medal, a diploma and a monetary award prize that has varied throughout the years.[3] In 1901, van 't Hoff received 150,782 SEK, which is equal to 7,731,004 SEK in December 2007. The award is presented in Stockholm at an annual ceremony on 10 December, the anniversary of Nobel's death.[4]

At least 25 laureates have received the Nobel Prize for contributions in the field of organic chemistry, more than any other field of chemistry.[5] Two Nobel Prize laureates in Chemistry, Germans Richard Kuhn (1938) and Adolf Butenandt (1939), were not allowed by their government to accept the prize. They would later receive a medal and diploma, but not the money. Frederick Sanger is one out of three laureates to be awarded the Nobel Prize twice in the same subject, in 1958 and 1980. John Bardeen, who was awarded the Nobel Prize in Physics in 1956 and 1972, and Karl Barry Sharpless, who won the Nobel Prize for Chemistry in 2001 and 2022, are the others. Two others have won Nobel Prizes twice, one in chemistry and one in another subject: Maria Skłodowska-Curie (physics in 1903, chemistry in 1911) and Linus Pauling (chemistry in 1954, peace in 1962).[6] As of 2022, the prize has been awarded to 189 individuals, including eight women: Maria Skłodowska-Curie, Irène Joliot-Curie (1935), Dorothy Hodgkin (1964), Ada Yonath (2009), Frances Arnold (2018), Emmanuelle Charpentier (2020), Jennifer Doudna (2020) and Carolyn R. Bertozzi (2022).[7]

There have been eight years for which the Nobel Prize in Chemistry was not awarded (1916, 1917, 1919, 1924, 1933, 1940-42). There were also nine years for which the Nobel Prize in Chemistry was delayed for one year. The Prize was not awarded in 1914, as the Nobel Committee for Chemistry decided that none of that year's nominations met the necessary criteria, but was awarded to Theodore William Richards in 1915 and counted as the 1914 prize.[8] This precedent was followed for the 1918 prize awarded to Fritz Haber in 1919,[9] the 1920 prize awarded to Walther Nernst in 1921,[10] the 1921 prize awarded to Frederick Soddy in 1922,[11] the 1925 prize awarded to Richard Zsigmondy in 1926,[12] the 1927 prize awarded to Heinrich Otto Wieland in 1928,[13] the 1938 prize awarded to Richard Kuhn in 1939,[14] the 1943 prize awarded to George de Hevesy in 1944,[15] and the 1944 prize awarded to Otto Hahn in 1945.[16]

In 2020, Ioannidis et al. reported that half of the Nobel Prizes for science awarded between 1995-2017 were clustered in just a few disciplines within their broader fields. Atomic physics, particle physics, cell biology, and neuroscience dominated the two subjects outside chemistry, while molecular chemistry was the chief prize-winning discipline in its domain. Molecular chemists won 5.3% of all science Nobel Prizes during this period.[17]

Discussion

STOCKHOLM (AP) — Two scientists won the Nobel Prize in chemistry for finding an ingenious and environmentally cleaner way to build molecules — an approach now used to make a variety of compounds, including medicines and pesticides. The work of Benjamin List and David W.C. MacMillan has allowed scientists to produce those molecules more cheaply, efficiently, safely and with significantly less hazardous waste. “It’s already benefiting humankind greatly,” said Pernilla Wittung-Stafshede, a member of the Nobel panel. – Physics Nobel rewards work on climate change, other forces[18,19]

- 2 win medicine Nobel for showing how we react to heat, touch
- Activists, WHO in the frame as Nobel Peace guessing starts

It was the second day in a row that a Nobel rewarded work that had environmental implications. The physics prize honored developments that expanded our understanding of climate change, just weeks before the start of global climate negotiations in Scotland. The chemistry prize focused on the making of molecules. That requires linking atoms together in specific arrangements, an often difficult and slow task. Until the beginning of the millennium, chemists had only two methods — or catalysts — to speed up the process, using either complicated enzymes or metal catalysts. That all changed when List, of the Max Planck Institute in Germany, and MacMillan, of Princeton University in New Jersey, independently reported that small organic molecules can be used to do the job. The new tools have been important for developing medicines and minimizing drug manufacturing glitches, including problems that can cause harmful side effects. Johan Åqvist, chair of the Nobel panel, called the method as “simple as it is ingenious.” “The fact is that many people have wondered why we didn’t think of it earlier,” he added. MacMillan said that winning the prize left him “stunned, shocked, happy, very proud.” “I grew up in Scotland, a working-class kid. [20,21]My dad’s a steelworker. My mom was a home help. … I was lucky enough to get a chance to come to America, to do my Ph.D.,” he said. In fact, he said at a news conference in Princeton, he was planning to follow his older brother into physics, but the physics classes in college were at 8 a.m. in a cold and leaky classroom in rainy Scotland, while the chemistry

courses were two hours later in warmer, drier spaces. As he told that story, he said he could hear his wife pleading with him not to share it. His said the inspiration for his Nobel-winning work came when thinking about the dirty process of making chemicals — one that requires precautions he likened to those taken at nuclear power plants.

If he could devise a way of making medicines faster by completely different means that didn't require vats of metal catalysts, the process would be safer for both workers and the planet, he reasoned. List said he did not initially know MacMillan was working on the same subject and figured his own hunch might just be a "stupid idea" — until it worked. At that eureka moment, "I did feel that this could be something big," [22,23]the 53-year-old said. H. N. Cheng, president of the American Chemical Society, said the laureates developed "new magic wands." Before the their work, "the standard catalysts frequently used were metals, which frequently have environmental downsides," Cheng said. "They accumulate, they leach, they may be hazardous." The catalysts that MacMillan and List pioneered "are organic, so they will degrade faster, and they are also cheaper," he said.[24]

The Nobel panel noted that their contributions made the production of key drugs easier, including an antiviral and an anti-anxiety medication. "One way to look at their work is like molecular carpentry," said John Lorsch, director of the National Institute of General Medical Sciences at the U.S. National Institutes of Health. "They've found ways to not only speed up the chemical joining," he said, "but to make sure it only goes in either the right-handed or left-handed direction." The ability to control the orientation in which new atoms are added to molecules is important. Failing to do so can result in side effects in drugs, the Nobel panel explained, citing the catastrophic example of thalidomide, which caused severe birth defects in children. Since the scientists' discovery, the tool has been further refined, making it many times more efficient. Peter Somfai, another member of the committee, stressed the importance of the discovery for the world economy. "It has been estimated that catalysis is responsible for about 35% of the world's GDP, which is a pretty impressive figure," he said. "If we have a more environmentally friendly alternative, it's expected that that will make a difference." The NIH supported List's research with a grant in 2002. MacMillan's work has received funding from NIH since 2000, for a total of around $14.5 million to date. "It's a great example of supporting basic science that you don't necessarily know where it's going to go" but can have major impact, said Francis Collins, NIH director. The Nobel comes with a gold medal and 10 million Swedish kronor,, or more than $1.14 million. The money comes from a bequest left by the prize's creator, Swedish inventor Alfred Nobel, who died in 1895.Over the coming days, Nobels will be awarded in literature, peace and economics. Jordans reported from Berlin and Larson from Washington. Associated Press journalists Mike Corder in Amsterdam and Ted Shaffrey in Princeton, New Jersey, contributed.[25]

Results

Two scientists have won the 2021 Nobel prize in chemistry for the discovery of a new class of catalyst that has revolutionised the development of drugs and hi-tech materials. The winners, Scottish-born David MacMillan, and Benjamin List from Germany, will share the award, presented by the Royal Swedish Academy of Sciences and worth 10m Swedish kronor (£870,000).The pair independently found that organic molecules can be used as catalysts. Before the breakthrough in 2000 there were just two classes of catalyst available: metals and enzymes, each of which have drawbacks. The new technique, asymmetric organocatalysis, has been widely applied in drug development and the discovery of new materials for electronic devices such as solar panels. Organic catalysts are also environmentally friendly and cheap to produce. "I am shocked and stunned and overjoyed," MacMillan said, adding that he noticed a few texts from Sweden on his phone early in the morning and thought it was a prank so went back to sleep. "Then my phone started going crazy." MacMillan said the concept of organic catalysts was a "pretty simple idea" that had sparked off research in lots of different directions. "What we care about is trying to invent chemistry that has an impact on society and can do some good, and I am thrilled to have a part in that," he said. Speaking on Wednesday from Amsterdam, where he is on holiday with his family, List said he was "deeply honoured" by the award. "I absolutely didn't expect this huge surprise," [26,27] he said. List made his discovery while at the Scripps Research Institute in southern California, where he decided to investigate whether a small subunit of an enzyme, called an amino acid, could act as a catalyst by itself. Taking a lead from an obscure line of research that had tailed off in the 1970s, he found that the amino acid, proline, was an extremely efficient catalyst and immediately recognised the wider significance of his discovery. "When I first did this experiment I didn't know what would happen, whether it was a stupid idea or if someone else had done it already," said List. "When it worked I did think: 'This could be something big.' Of course, I didn't expect this."[28]

MacMillan triangulated on the same discovery after a stint working on metal catalysts. He had become frustrated that research in the field rarely found industrial applications because the metals involved were so expensive and needed an environment free of oxygen and moisture to work. An added downside is that many metal catalysts are heavy metals, which can be harmful to the environment. Based at University of California, Berkeley, MacMillan identified several simple organic molecules, which, as metal catalysts do, could temporarily provide or accommodate electrons in chemical reactions, making them ideal catalysts. A huge advantage of the technique is that it produces asymmetric molecules – that is, just one version of molecules that come in a pair of mirror-image forms. This is crucial when producing medicines, because the body can react completely differently to the left-handed and right-handed versions of the same chemical. A catastrophic example of this was with the drug thalidomide, which was used widely to treat morning sickness in the 1950s and 60s, but was later withdrawn when it was found to cause disabilities in babies born to mothers who had taken it. The drug contained two mirror versions of the same chemical compound, one of which was dangerous to the developing foetus. “This concept for catalysis is as simple as it is ingenious, and the fact is that many people have wondered why we didn’t think of it earlier,” said Johan Åqvist, the chair of the Nobel committee for chemistry.[29]

Conclusion

How far back does your family tree reach? The winner of the 2022 Nobel Prize in Physiology and Medicine just added a few thousand years. Swedish geneticist Professor Svante Pääbo discovered the genetic identity of two of humankind’s earliest ancestors, opening a new window on human evolution in the process. He was the first winner of this year's six Nobel Prizes that are being announced between 3 and 10 October. Here's what you need to know about his discovery - and the recipients of the other Nobel Prizes 2022, including the prizes for Literature and Peace... Prof Pääbo, Director of the Max Planck Institute for Evolutionary Anthropology in Leipzig, achieved what many scientists believed to be impossible when, in 2010, he sequenced the genome of the Neanderthal, an extinct relative of present-day humans. He went on to discover a previously unknown branch of the human family tree by extracting DNA from a 40,000-year-old finger bone found in a cave in Siberia. The new hominid was named Denisova after the location in which the bone was discovered. Announcing the award, Professor Nils-Göran Larsson, Chair of the Nobel Committee, said: “His discoveries help us to understand homo sapiens, present-day humans. This is a very fundamental, big discovery. “On average, you and I have one to two per cent Neanderthal DNA… [they] are our closest extinct relatives that now have been defined at the genome level. Over the years to come, this will give huge insights into human physiology.” Neanderthal people became extinct in Europe 30,000 years ago, only a few millennia after the appearance of modern humans. This prompted scientists to speculate that their disappearance may have been due to conflict with homo sapiens. Winning Nobel Prizes in the Physiology and Medicine category is something of a family tradition for Professor Pääbo - his father, biochemist Sune Bergström, won the Nobel Prize in medicine in 1982. It's the ninth time that a child of a Nobel laureate has also won a prize. Scientists Alain Aspect, John Clauser and Anton Zeilinger won the 2022 Nobel Prize in Physics for experiments in quantum mechanics that laid the groundwork for rapidly-developing new applications in computing and cryptography." Their results have cleared the way for new technology based upon quantum information," the Royal Swedish Academy of Sciences said of the laureates: Aspect, who is French, Clauser, an American and Zeilinger, an Austrian. The scientists all conducted experiments into quantum entanglement, where two particles are linked regardless of the space between them, a field that unsettled Albert Einstein himself, who once referred to it in a letter as "spooky action at a distance". "I'm very happy... I first started this work back in 1969, and I'm happy to still be alive to be able to get the prize," Clauser, 79, told Reuters by phone from his home in Walnut Creek, California.

Carolyn Bertozzi, Morten Meldal and Barry Sharpless have won the 2022 Nobel Prize in Chemistry 'for the development of click chemistry and bioorthogonal chemistry.' Past chemistry winners include well-known scientific names such as Marie Curie, who also shared the physics prize with her husband and whose eldest daughter, Irene Joliot-Curie, won the chemistry award just over two decades after her mother. “This year’s Prize in Chemistry deals with not overcomplicating matters, instead working with what is easy and simple. Functional molecules can be built even by taking a straightforward route,” says Johan Åqvist, Chair of the Nobel Committee for Chemistry. The award is Sharpless's second Nobel Prize in Chemistry.

The Prizes were first awarded in 1901 by The Nobel Foundation, a private institution established in 1900, to carry out the wishes of Swedish chemist, engineer and industrialist Alfred Nobel, the inventor of

dynamite, who died in 1896.He left the bulk of his fortune in trust to establish the international awards that bear his name. To date, Nobel Prizes have been awarded 609 times to 975 people and organizations, or 943 individuals and 25 organizations if you count those who have won twice. Undoubtedly all Nobel Prize winners deserve to be famous but here are some of the best known:

Marie Curie (Physics 1903, Chemistry 1911) for her work on radioactivity (1903) and for discovering radium and polonium (1911).

Albert Einstein (Physics 1921) “for his services to Theoretical Physics, and especially for his discovery of the law of the photoelectric effect”.

International Committee of the Red Cross (Peace 1917, 1944, 1963).

Sir Alexander Fleming (Physiology or Medicine 1945) for discovering penicillin the foundation for the development of all modern antibiotics.

James Watson, Francis Crick, and Maurice Wilkins (Physiology or Medicine, 1962) for discovering the helix structure of DNA. The award caused controversy because it overlooked the contribution of Rosalind Franklin whose research was vital to their discovery. In 2019 Watson was stripped of the prize over comments he made about race.

Dr Martin Luther King, Jr. (Peace, 1964) awarded for his work on civil rights in the United States. At the time he was aged 35, the youngest man to have received the Nobel Peace Prize. He gave the $54,123 to the civil rights movement but was assassinated in 1968, just four years after receiving the award.[29]

Gabriel García Márquez (Literature, 1982) for "for his novels and short stories, in which the fantastic and the realistic are combined in a richly composed world of imagination, reflecting a continent's life and conflicts".

Mikhail Gorbachev (Peace 1990) for his role in bringing the Cold War between the Soviet Union and the West to a peaceful conclusion.

Nelson Mandela (Peace, 1993), South Africa’s first Black president who brought about an end to apartheid and shared his prize with the country’s last white president F.W. De Klerk who handed over power peacefully.

Former US President Jimmy Carter (Peace, 2002) “for his decades of untiring effort to find peaceful solutions to international conflicts, to advance democracy and human rights, and to promote economic and social development”.

Malala Yousafzai (Peace, 2014) an educational campaigner and the youngest ever Nobel Laureate who won the prize after being shot and severely wounded by a Taliban gunman for defying their ban on female education. She now heads the Malala fund that campaigns for female education rights worldwide.[29]

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