# THE PARTICLE AND THE PRIZE

FOR MORE THAN A CENTURY, THE NOBEL PRIZES HAVE REPRESENTED THE ZENITH OF SCIENTIFIC ACHIEVEMENT. BUT ARE THEY AN ACCURATE REFLECTION OF SCIENCE AS IT IS DONE TODAY? **WILSON DA SILVA** FINDS THAT THE WINDS OF CHANGE ARE BLOWING IN STOCKHOLM.

Sitting in the magnificent Blue Hall of the Stadshuset, listening to a trio of sopranos singing from a Swedish opera, while sipping from a flute of Gaston Chiquet Cuvée Tradition, it's easy to be transported by the mythical dimensions of the evening. Here on the Riddarfjärden waterfront of central Stockholm on 10 December each year the world's most exclusive science party celebrates the pinnacle of scientific achievement. Only a very select few get to sit on the table of honour with Sweden's King Carl Gustaf, who annually rises to offer a toast in memory of Alfred Nobel.

But for some, the Nobel Prize has lost a little of its glow. Determining who should win, and for what, is subject to rules that were mostly drafted 114 years ago. At that time, science was a genteel endeavour carried out by brilliant individuals working, mainly, in isolation. That just three individuals are awarded for the pre-eminent advance in their field in any one year fits uncomfortably with the way science is done today. These days a breakthrough Nature paper is likely to devote half its title page to the names of contributing authors. And back-to-back with that paper, there's likely to be another paper or two, describing related results from the same research.

One of the four Nobel Prizes awarded on the glittering Riddarfjärden waterfront in 2013 was the Nobel Prize in Physics, shared between Britain's Peter Higgs and Belgium's François Englert. In the 1960s both predicted the existence of what has come to be known as the Higgs boson. This particle is held to be responsible for giving other particles mass, making it the foundation for the entire Standard Model of physics. Their insight proved the power of theoretical physics in a way not seen since the days of Albert Einstein.

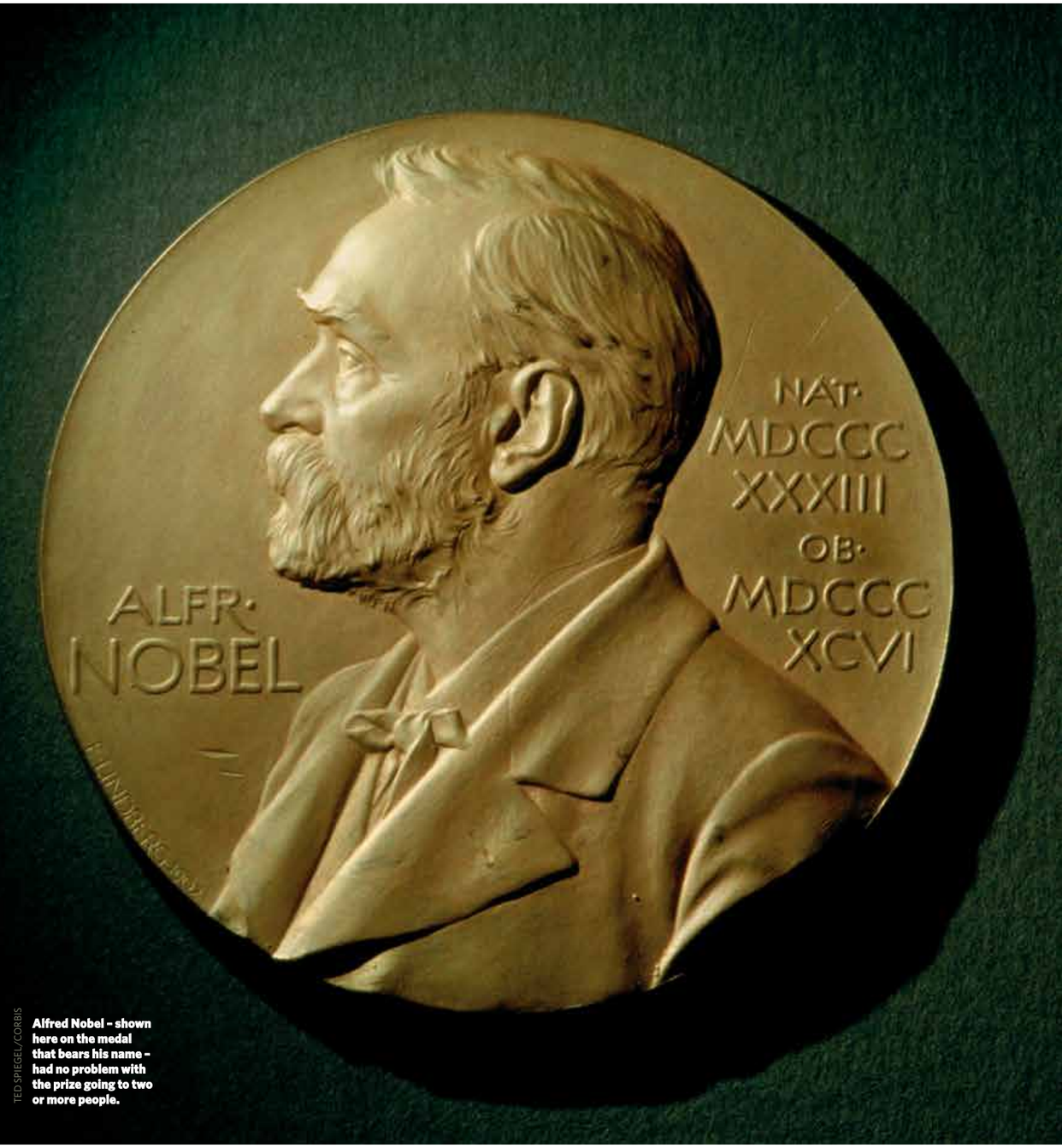
Yet the 2013 Nobel Prize for Physics also perfectly exemplifies the mounting doubts about the Nobels. It's a growing controversy that is clearly not far from the minds of the Royal Swedish Academy of Sciences selection committee, even as they narrow the shortlist for this year's prize.

Peter Higgs is a little like the particle that bears his name. He's not easy to find, scarcely interacts with others, and yet, when he moves through a crowd, people cluster around him as if some invisible force is drawing them closer.

He sports a dark suit and a severe demeanour, but he's affable when he speaks about his work. His wispy white eyebrows draw together and occasionally a crooked smile breaks out. The emeritus professor of the University of Edinburgh doesn't own a television, was only recently convinced to acquire a mobile phone, and the laptop he was given baffles him so much he doesn't use it. At almost 85, he's a little hard of hearing. He and Englert had to wait a long time for their Nobel Prize. In 1964 the two physicists independently proposed a theory to explain how particles acquire mass. It involved the existence of a new subatomic particle, with zero electric charge, that would impart mass to the other particles.

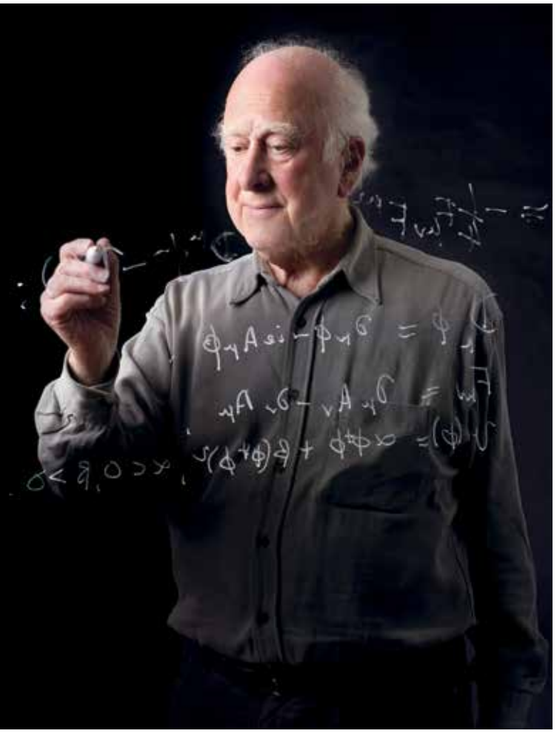
But it took until 2012 and the largest and most expensive machine ever made – the Large Hadron Collider (LHC) – to find it. After billions of particle collisions, two teams of researchers finally detected the tell-tale spike that heralded the particle's existence. Now known as the Higgs boson, the particle has become famous enough to be mentioned on The Simpsons, even if most people have no idea what it is.

Back in the 1960s, when Higgs and Englert first proposed the boson's existence, they were met "with a deafening silence" which, Higgs told COSMOS, was at least partly justified. "It was a theory in search of the correct application … it wasn't until 1967 that it became a realistic thing to think about whether it was going to be verified or not." That year




TED SPIEGEL/CORBIS

**Alfred Nobel – shown here on the medal that bears his name – had no problem with the prize going to two or more people.**



SPL CREATIVE/GETTY IMAGES AND CERN/MICHAEL HOCH

**Elusive British physicist Peter Higgs, above left, is a little like the particle that bears his name**

**Nobel Prizes can be shared by no more than three scientists, but hundreds contributed to finding the Higgs boson at CERN, above right.**

American physicists Steven Weinberg and Sheldon Glashow and the late Pakistani physicist Abdus Salam proposed another theory that put the Higgs boson at its centre. Their theory unified the weak force, which describes some types of radiation, and the electromagnetic force, in what was dubbed the "electroweak theory". They also predicted two new types of particle known as W and Z bosons. The unified theory won them the Nobel Prize for Physics in 1979. Four years later, the trio's work was validated when W and Z bosons were detected by the particle accelerator called the Super Proton Synchrotron built at CERN in Geneva.

The electroweak theory predicted three types of boson. Two had been found, leaving only the Higgs. The last vestiges of resistance among the physics community dissolved. The hunt to find the Higgs boson was well and truly on, culminating finally in the decision to construct the biggest, most expensive supercollider the world had ever seen, also at CERN. In a chain of events that reprised the discovery of the W and Z bosons three decades before, the Higgs was finally discovered in 2012 and celebrated at last with the 2013 Nobel Prize.

But tragedy lies beneath the celebration. Englert's Higgs boson paper was written with his friend and colleague Robert Brout, an American-born theoretical physicist who went on to make further noted contributions to particle physics. Like Englert he was a professor of physics at Université Libre de Bruxelles. But the 82-year-old New Yorker passed away in May 2011 – and that disqualified him from the Nobel Prize. Had Brout been alive, would he have made the lavish party, and received the recognition his role deserved? Higgs has no doubt, "The fact that [the Nobel committee] just stopped at two, to me, suggests that Robert Brout is being implicitly recognised as one of three who might have got it, had he been alive."

Many have been upset by the rule that winners must be living at the time of the announcement. Yet, this is a recent amendment. Before 1974, Nobel prizes were awarded posthumously twice – to United Nations Secretary-General Dag Hammarskjöld (1961 Nobel Peace Prize) and Swedish poet Erik Axel Karlfeldt (1931 Nobel Prize for Literature).

Even more problematic is the rule that a maximum of three people can share the prize. Three other physicists also made key contributions to the Higgs theory in 1964 – Gerald Guralnik, Tom Kibble and Carl Hagen – and Kibble followed up with a paper in 1967 that Higgs calls "very influential". That paper, he believes, made Kibble worthy of sharing in the 2013 prize.





VIRGINIE LEFOUR/AFP/GETTY IMAGES

**Belgian physicist and Higgs' fellow Nobel Prize winner Francois Englert, above. His colleague, Robert Brout, who worked on a Higgs boson paper with him, died before the prize was awarded.**

## + FRONTIER SCIENCE REQUIRES ELABORATE ENGINEERING, WITH INTERNATIONAL TEAMS

Hagen, now a professor of physics at the University of Rochester, believes the Swedish academy should have been less stringent about its rules. "I would have hoped that they would've found it in their heart of hearts to include all five of us." Kibble, an emeritus professor at Imperial College London, agrees, despite the fact that Higgs, Englert and Brout published their work a month or two earlier.

Is a restriction to three prize-winners still relevant in a world where major advances often can only be made with large teams of scientists? "The rule of three also reinforces the idea that science is carried out by a handful of geniuses, toiling by themselves in ivory towers," *The Economist* notes in an editorial following the announcement of Englert and Higgs' elevation to the Nobel pantheon. "If that was ever true, it isn't now."

These days, frontier science requires elaborate engineering, often with international teams. Papers with five or more authors are common in many disciplines. At CERN, the Higgs boson was finally unmasked by the ATLAS and CMS (the compact muon solenoid experiment) teams, each of which involves over 3,000 people from around the world. Each team constructed highly complex detectors to study proton collisions in the Large Hadron Collider, itself a mind-bogglingly sophisticated instrument built from the intellectual toil of thousands of people and scores of institutes. The pair of papers in *Physics Letters B* detailing the discovery of the Higgs boson had more than 5,000 authors from more than 200 institutions. What's strange is that the original Nobel statutes allowed that the prize could go to "two or more persons together". In 1968 it was amended to read, "in no case may a prize be divided between more than three persons."

What's more, only individuals have ever been recognised, not institutions. That's not the case with the Nobel Peace Prize, separately administered by Norway, which has given the medal to organisations like the International Red Cross and, in 2013, the Organisation for the Prohibition of Chemical Weapons. In fact, the rules explicitly permit

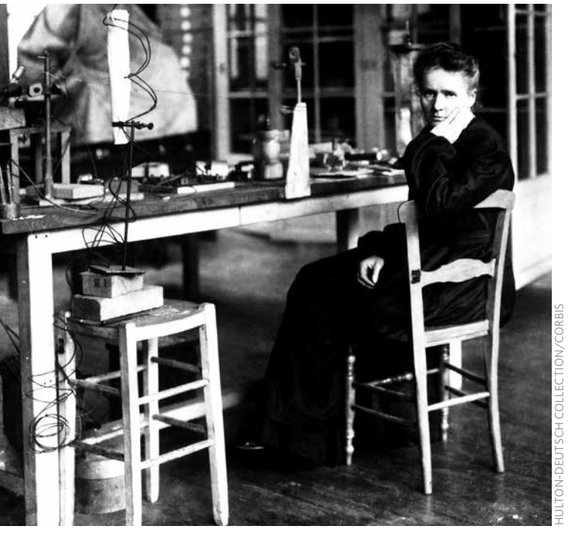
awards to organisations. Prizes "… may be conferred upon an institution or association".

Despite Englert and Higgs being widely tipped to take the 2013 Physics prize, the announcement on 8 October – made shortly after a meeting of the physicists in the Academy of Sciences – was uncharacteristically delayed by more than an hour. Rumours circulated that some academicians led a last-minute push to anoint CERN as the third winner, as permitted by the statutes. Others held that arguments were put for Kibble to be recognised as the third joint winner.

It will take 50 years till we know the answer; that's the time that must elapse before the veil of secrecy surrounding the deliberations on each prize can be lifted.

Lars Bergström is a dapper man in his late 50s with pleasant Nordic features, greying hair and an easy smile. He has been the secretary of the Nobel Committee for Physics at the Royal Swedish Academy of Sciences for a decade. An astrophysicist at Stockholm University working on dark matter, he's also worked at CERN, is on the editorial board of the *Journal of High Energy Physics*, and was recently elevated to the board of the Nobel Foundation, which administers all six Nobel Prizes. More than anyone, he is responsible for shepherding the selection of candidates for the Physics Prize from nomination to ratification. And it's no cakewalk.

**+ THE MOST COMMON COMPLAINT IS OVER THE SHALLOW POOL OF FEMALE WINNERS.**



HULTON-DEUTSCH COLLECTION/CORBIS

**Women are under-represented when it comes to Nobel Prizes. Marie Curie did her bit to even the score – she won two, one for physics and her work with radioactivity and another in chemistry for discovering radium and polonium.**

Every September, before the current year's winners are even announced, confidential invitations to nominate candidates for the next year are sent out to around 3,000 professors of physics in Sweden, Denmark, Finland, Iceland and Norway, to physics professors from at least six universities outside Scandinavia, and to "other scientists from whom the Academy may see fit to invite proposals". The deadline is 31 January, and the reply rate for completed nomination forms is around 35%.

In February, the seven-person Nobel Committee for Physics – five men and two women, all at Swedish universities – selects the preliminary candidates from the 300 or so names. This selection is presented to a meeting of the physics members of the Academy – known as the Physics Class. About 20 discoveries are examined in detail, with reports commissioned from experts. By May, the reports come in and the committee pares down the list and prepares a detailed proposal over the northern summer. The Physics Class also gets these reports and can, if it chooses, write competing proposals.

In September, the committee submits its final recommendations to the Physics Class and, based on its feedback, selects the winners and writes their citations. In early October – just hours before the announcement is due – the Physics Class meets one last time to review the citations and formally elects the winners. The decision, made via majority vote, is final and without appeal.

At this final meeting the Physics Class can, in principle, overrule the committee's selection, adding or subtracting winners or altering citations. As soon as a selection is made, Nobel Foundation staff scramble to contact the winners directly, with just a 30-minute window before the media conference announcing them. Peter Higgs, who didn't have a mobile phone and was on his way home after a leisurely lunch in Edinburgh, was unaware that he had won until a former neighbour stopped him in the street to offer congratulations.

The process mostly works. Candidates cannot nominate themselves, and would disadvantage their case if they tried to intervene in any way. Lobbying on behalf of certain discoveries or candidates is looked down upon, although Swedish journalists who have covered the Nobels say it does occasionally happen behind the scenes.

But the process doesn't ensure that every deserving contribution to science is rewarded – often because of self-imposed restrictions. The list of examples is legendary and long.

Take the 2008 Nobel Prize in Physics, awarded to the Japanese trio of Yoichiro Nambu, Makoto Kobayashi and Toshihide Maskawa, for their discovery in the 60s and early 70s of the origins of "broken symmetry". This predicted the existence of at least three families of quarks – types of subatomic particles. (Nambu's work inspired Higgs to develop his own theory.) Many felt that Italian physicist Nicola Cabibbo also deserved the award, as his work on two quark families laid the foundation for Kobayashi and Maskawa. Cabibbo was undoubtedly a key player in theoretical physics during that productive period, Higgs recalls.

Asked at the time for his reaction to the prize, Cabibbo gave no comment, but reportedly told friends he was embittered by the decision. To this day, physicists acknowledge his place by referring to the discovery as the Cabibbo-Kobayashi-Maskawa matrix.

Another example is the 1965 Nobel Prize for physics won by Japan's Sin-Itiro Tomonaga and Americans Julian Schwinger and Richard Feynman, for their fundamental work in quantum electrodynamics – the physical laws that describe how light interacts with matter and charged particles interact with each other. British theoretical physicist and mathematician Freeman Dyson was the one who mathematically proved their three approaches were equivalent, yet he missed out. Weinberg (1979 Nobel Physics Prize) told *The New York Times* that the committee "fleeced" Dyson. Now 90, his chances of being awarded a prize are slim.

SPL CREATIVE/GETTY IMAGES

**German radiochemists Lise Meitner and Otto Hahn were the first to obtain nuclear fisson, but only Hahn was awarded the Nobel Prize.**

But perhaps the most common complaint levelled at the Nobel Prizes is over the shallow pool of female winners. Of the 195 individuals honoured for physics, only two are women: Marie Curie in 1903 for her work on radiation and Maria Goeppert-Mayer in 1963 for discoveries concerning the structure of the nuclear shell. Across all the prizes the statistics are better, but hardly laudable, and they are a repeated source of criticism. Out of 680 in total, there have been 43 Nobel prizes awarded to women.

Bergström concedes that, in the past, a tendency to recognise male researchers ahead of women may have played a part. He cites the example of Lise Meitner, who first realised how nuclear fission might be triggered and did a lot of the core mathematics. Meitner, an Austrian Jew, collaborated with German chemist Otto Hahn for 30 years, and they worked together at the Kaiser Wilhelm Institut in Berlin until she was forced to leave Nazi Germany. She moved to Sweden to work with her nephew, physicist Otto Frisch, but continued the collaboration with Hahn by correspondence. Letters between the two indicate Meitner gave Hahn valuable insights that helped him tweak the experiments that led to nuclear fission. Hahn, still in Berlin, published in the German journal *Naturwissenschaften* in 1938 without listing Meitner as a co-author – ostensibly because of the sensitive politics of collaborating with a Jew. He also abstained from making the claim that it was fission he had achieved. Meitner and Frisch later correctly interpreted his results as being nuclear fission, and published a paper in *Nature*. Frisch confirmed the results experimentally the following year, and even coined the term 'fission'. Nevertheless, Hahn was the solitary recipient of the 1944 Chemistry Prize "for his discovery of the fission of heavy nuclei".

Bergström would like to see more women in the Nobel pantheon, especially in physics, but says the Nobel committees are hamstrung by the fact they rely on nominations – and so few women are proposed, especially in physics. Another factor is the long lag times between discovery and experimental confirmation. Take the 2013 prize – it was for work done in the early 1960s, when very few women worked in physics.

Nevertheless, he's a little defensive. "Well, two of the [committee] members are women; one of them has been there for six or seven years. I mean, we shouldn't blame her that she doesn't find women either, right?"

The Royal Swedish Academy of Sciences is housed in an imposing neo-classical building perched on a windy hill overlooking Haga Park on the northern outskirts of Stockholm. Inside is the room where the Nobel Committee for Physics meets, furnished in dark wood and adorned with a bust of Alfred Nobel. The snow is heaped outside, and the interior festooned with portraits of great men of science, many dating back centuries.

The institution may be "rather conservative" Bergström says, as soft winter light emanates from the window. But he hints that calls for the Nobel Prizes to adapt to 21st century science are not going unheeded.

"There is a possibility that the Academy will change its habits of isolating two or three people, because that's really what Alfred Nobel wanted, that's written in his will."

He also notes that the Peace Prize recognises institutions, which in principle the Academy can also do. "Maybe in the future, one would have to do that. If you ask me, I think that maybe in 10 years we might do that, because so much of science these days is done in big collaborations."

On 10 December 2013 the first nominations for the 2014 Physics Prize were already coming in, and before the interview, Bergström spent a couple of hours going through them. But tonight, he's looking forward to the awards ceremony in the palatial Stockholm Concert Hall, followed by the opulent banquet. He rises – white tie and tails are waiting for him at home. "Soon, the hard work starts… but this, this is a great time of the year."

**Wilson da Silva** is a science writer in Sydney, and the former editor-in-chief of *COSMOS*.