How to win a science Nobel Prize

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The selection of a Nobel awardee is connected with massive appreciation, expansion and focus on the scientific topic, and international attention. For many countries, this is the ultimate recognition. Therefore, the hope to receive a prize is not only an important scientific goal, but also a political focus. Nevertheless, only few scientists live up to the demands of receiving the prestigious award.

I should start by saying that there is of course no foolproof recipe for how to get a Nobel Prize in any of the three science categories, Physics, Chemistry, and Physiology or Medicine. In a recent article in BioZoom (1), professor Janine Erler described very well how to be a top scientist today. One can say that her description forms a baseline for winning a Nobel Prize. There are, however, many top scientists, and only a maximum of nine that can be awarded Nobel Prizes during a given year (Figure 1).

Many worthy scientists cannot be awarded, and many distinguished scientists can have very impressive records but lacking the peak with a height sufficient for a Nobel Prize. To give an example; Arnold Sommerfeld was nominated no less than 84 times for the physics prize over a time span of 34 years (1917 to 1951). Sommerfeld had been the thesis supervisor of some of the greatest physicists of the 20th century (Wolfgang Pauli, Werner Heisenberg), yet it was clear to the Nobel Committee for Physics already in the early 1920s that his contribution constituted an improvement of the 1913 Niels Bohr model of the atom, not a discovery as

Figure 1. *The opening speech by professor Carl-Henrik Heldin at the Nobel Prize Award Ceremony 2017. © Nobel Media AB 2017, Alexander Mahmoud.*

Figure 2. *The timeline for the selection and award of a Nobel Prize.*

required by Nobel's will for the field of physics (2).

This article will focus more on the prerequisites on a national level for winning a Nobel Prize rather than discussing how an individual scientist should act. An overlap between the national and individual levels is, however, unavoidable.

To begin with, it is worth pointing out the criteria for awarding a Nobel Prize, as outlined in the will of Alfred Nobel (2). I have noted that this is not always clear even to experienced scientists, and there are differences between the three areas that affect the leeway for a Nobel Committee. A "discovery" or "invention" is required for the physics prize, a "discovery or improvement" for the chemistry prize, whereas the prize in physiology or medicine has the most restrictive formulation: "discovery".

One question which is often posed is "why didn't *X* get the prize for the discovery (or invention or improvement) of *Y*?" While this question can be answered quite well for prizes older than 50 years, for which a historian of science can consult the written records (nominations, expert reports, and the deliberations of the committees), the 50-year-rule precludes this for younger prizes. A help here is to carefully read the citation. Did *X* really fulfil the requirements for prize *Y* as formulated in the citation?

Another requirement more difficult to interpret is Alfred Nobel's general statement for all five prizes (including literature and peace) that a prize should be awarded to those who "shall have conferred the greatest benefit to mankind". Nobel Prizes cannot be awarded posthumously, but had Louis Pasteur outlived Alfred Nobel by five years or more (Pasteur died just over a year before Nobel), he would have been awarded the Nobel Prize in physiology or medicine with a motivation fulfilling perfectly the requirements for "greatest benefit to mankind".

The nominations sent to the committees by individual scientists form the basis for the selection of Nobel Prizes. A minimum of one nomination is required during a given year in order for the committees to consider someone for a prize. The Nobel Committees send out about 3000 letters asking for nominations each year (3), and receives about 250-350 names to consider in physics and chemistry (in physiology or medicine this number is not publically disclosed). The universities all around the world have an important role to play in this process; if a university is asked to help in the nomination process, it should select scientists at its university and ask them to make individual nominations. A careful selection of scientists with a broad view on science and interested in making a contribution, is most helpful to the Nobel Committees. Figure 2 shows the timeline for selection and award of a Nobel Prize.

It seems like different countries value a Nobel Prize in different ways. To give an example: In Japan a Nobel Prize is a matter of national pride, whereas in the US it is valued more on the university level. Theoretical physicists of Japanese origin told me how important the first Japanese Nobel Prize was, the one to Hideki Yukawa in physics in 1949 "for his prediction of the existence of mesons on the basis of theoretical work on nuclear forces". It demonstrated that Japanese science was capable of originality on the highest level, not only "copycat". Figure 3 shows the back side of the Nobel Prize medal in physics and chemistry.

Between 1901 and 1999, Japanese scientists won five Nobel Prizes. Since the year 2000, no less than 17 Japanese scientists have won the prize. Increased funding of research has been put forward as one possible, maybe likely, explanation. Japan has one of the highest ratios of researchers in the world, 70.2 to 1000. The number grew until about 2008 and then stagnated. In a meeting at UC Berkeley in November 2017 (4), which I attended, Japanese scientists expressed a concern that the stagnation in research funds would break the trend in Japanese scientists winning Nobel Prizes.

It is undisputable that the way a country organizes its university system influences the chances for winning a Nobel Prize. Germany developed a strong university system during the 19th century, and when Albert Einstein in 1922 was awarded the 1921 year's Nobel Prize in Physics, he was number 20 in Germany to receive a science Nobel Prize since 1901.

During the same period, the US received only two science Nobel Prizes. After the Second World War, the US has

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Figure 3. *The Nobel prize medal in Physics and Chemistry (back side). © ® The Nobel Foundation. Reproduced with permission and licence from The Nobel Foundation.*

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been the dominant country in collecting Nobel Prizes. This is owing to a combination of a very strong university system (5) combined with a well thought-out funding system. A tenured professor, even a young one, enjoys a very high degree of job security. That this has been essential for Nobel laureates is obvious from interviews; they have been prepared to take risks since their job was not on the line, and risk-taking is an essential element in research that has potential for true scientific breakthroughs. The funding agencies need to be prepared for long-term commitments, but also for aggressive interferences when a promising project stands the risk of collapsing. Last year's physics prize is a good example. The US National Science Foundation played an important role in putting LIGO on the right track (6).

Somewhat paradoxically, my own country Sweden, the Nobel Prize awarding country, has had considerable difficulties in designing a research system with optimal balancing factors. The career system has been obsolete, and when it has been renewed, it has happened without much preparations and lack of funding. The public funding system has been too conservative, lacking stimulus for renewal and risk-taking. There is a legitimate concern that Sweden is falling behind other small countries, such as Denmark, the Netherlands and Switzerland.

What we can say with certainty, however, is that the unique situation Denmark enjoyed during the Niels Bohr era can never be planned. It just happens, and when it happens it is truly remarkable.

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