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A Century of Nobel Prizes **

The Nobel Prizes is a unique institution. At the time when it was conceived it was the largest prize ever and it was international. Over the years it has acquired the status of being a unique measure of scientific quality. Since this is the 100th year when it has been possible to select Nobel Prize recipients it may be appropriate to consider what we can learn from examining the selection process and the anointed scientists.

The will

Alfred Nobel wrote his final will in November 1895. It was written in Swedish and deposited in a Swedish bank. He wrote it without any legal assistance. As a result there were a number of formal defects, which led to a series of complications before the will eventually could be implemented. Alfred Nobel had no immediate heirs. His closest relatives were his two nephews, one living in Sweden and one in Russia. When the will was opened five days after Nobel's death at 63 years on December 10, 1896, the relatives learnt to their dismay that only a limited portion of the estate was bequested to them.

Why then was it Nobel's wish that his estate should be used for prizes? It is said that his political views had a socialistic colour and that he did not sympathise with transfer of wealth between generations. Since he himself was a true inventor (355 patents were registered in his name) he could appreciate the importance of providing creative conditions for young talented inventors. His concept was simple. The prize to be given should allow the awardee to concentrate on his work without any need for income for some 20 years.

The five equal parts of the financial returns of the endowment should be given to the one (a) who in the field of physics has made the most important discovery or

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invention, (b) who in the field of chemistry has made the most important discovery or improvement, (c) who has made the most important discovery in the domain of physiology or medicine, (d) who in literature has produced the most outstanding contribution with an idealistic orientation and (e) who has worked the most or the best for fraternization between peoples and elimination or reduction of standing armies and formation and dissemination of peace congresses. The common determinator for the first three prizes is *discovery*. Thus prizes are not given for life contributions to science but for the making of single discovery with a huge impact. Only in a few cases is it possible to identify prizes in which a particular reference to the word "invention" and in particular "improvement" has been used. In the early years prizes in Physics were given for inventions, like to Lippmann in 1908 for the colour photography technique, to Marconi and Braun in 1909 for radio transmission and to Dalén in 1912 for automatic regulators in lighthouses, but later prizes most often have gone to discoveries in basic sciences. Interestingly this year the Committees for Physics and for Chemistry fortuitously proposed candidates in fields of more applied science.

The prize awarding institutions were for physics and chemistry the Royal Swedish Academy of Sciences, for physiology or medicine the Karolinska Institute in Stockholm, for literature the Academy of Letters in Stockholm and for peace a five member committee selected by the Norwegian House of Parliament (Stortinget). Sweden and Norway formed a union until 1905, when it was peacefully resolved. Nobel's choice of the five fields has been a matter of many discussions.

Implementation of the will

There were many roadblocks to be removed before the will of Alfred Nobel could be fully implemented. There were legal formalities such as the jurisdiction over the will.

The critical resolution of matters was the establishment of the Nobel Foundation, an idea conceived by the young engineer Ragnar Sohlman, one of the two executors of the will. This Foundation was instituted on June 29, 1900, and thus recently celebrates its first 100 years of existence. The Nobel Foundation is an umbrella organisation managing the fund, fulfilling legal functions and arranging the Prize ceremony in Stockholm. However it should be emphasised that it is the awarding institutions that carry the sole responsibility for selecting Prize recipients (not winners — one doesn't win a Nobel Prize) and give them their Prize.

How many Prize recipients

It was not clear from the will if the Prize-awarding institutions should aim at selecting a single recipient or if there could be many prize recipients. Originally the possibility of allowing a split into three prizes per discipline was considered but

eventually it was decided that there could be a maximum of two distinct prizes. It was furthermore not originally regulated whether a single prize could be shared by one, two or more recipients. This was not settled until 1968, when a rule was introduced that there can be a maximum of 3 prize recipients in one discipline at the same time. This gives five different possibilities. A prize can be given for a single discovery to one person or shared equally between 2 or 3 persons. Alternatively a prize can be given for two distinct discoveries. One half of the prize may go to one recipient and the other to another, but one half of the prize may also be shared between two individuals, giving a total of three recipients. A single individual can receive repeated honours such as the prize in physics to Bardeen in 1956 and 1972 and the prize in chemistry to Sanger in 1958 and 1980. There is also the possibility of receiving repeated honours in different fields such as Marie Curie's prize in physics in 1903 and chemistry in 1911 and Pauling's prizes in chemistry in 1954 and in peace in 1962. A Nobel Prize needs not be given to individuals, it can also be given to institutions. This possibility has only been used for the Peace Prize, which on several occasions has been given to institutions. One example is the Red Cross, which in fact has received more than two prizes. In principle it is also possible to give prizes in the natural sciences field to institutions.

So what do the records of the preceding century show as concerns selection of one, two or three recipients in the field of physics, chemistry and physiology or medicine? Note that due to World War perturbancies there are six years in which no Prizes in Physics were given, eight years without Prizes in Chemistry and nine years without Prizes in Physiology or Medicine. In Physics the first 50 years show predominantly single prize recipients, but there is also a fair number of shared prizes. After the second World War the prizes are increasingly shared between two or three recipients. However we have now possibly reached a steady state in apportion of prizes in physics. This is of interest to consider since it is frequently argued that since modern physics in many areas to an increasing extent is carried out in teams, sometimes with many hundred collaborators, it will be hard to single out individuals. This is probably not true. There is always in a team a single or a few individuals who leads the group.

Also in chemistry there is some shift over time towards more than one (all in the first decade) or two recipients after the Second World War. In fact also in this field the distribution of prizes to one, two or three individuals has been rather stable the last decades.

Physiology or Medicine is the field in which over time the largest proportion of prizes has been given to three individuals, in 29 per cent of all cases. However it seems that the propensity towards selecting three prize recipients is not increasing with time during the last decades (if anything the tendency is the opposite). Thus even in a field of multidisciplinary nature like medicine there is frequently the individual or a few individuals, who make the difference in paradigmatic advances.

How to select Nobel Prize recipients

The part of the will that has not been possible to fulfil is that the prizes shall be given "… to those who during the preceding year have …". In practice this requirement has been interpreted to mean that the impact of the contribution to be awarded has been fully appreciated during the preceding year. As a consequence discoveries to be honoured generally have been made 10-20 years before the year of awarding the Prize. In fact there are examples of a time lag as long as 50 years as when Rous in 1966 received a Prize for his discovery of tumour-inducing viruses based on findings made in the 1920s. The few mistakes that were made frequently represent a too rush recommendation for a prize by a committee.

Another part of the will whicl requires continuous deliberations is that the contribution shall "be beneficial for mankind". The way the committees have interpreted this in their penetrating work is that high quality basic research in one way or the other results in discoveries that markedly advance our civilization. However the tasks for the committees become more and more challenging. The number of scientists engaged in research increases with time and the number of paradigmatic discoveries probably also increases as a consequence. Possibly, therefore, more considerations may have to be given to the timelessness of a particular Prize in the future.

The total number of persons receiving Nobel Prizes in Physics, Chemistry and Physiology or Medicine during the previous century is 469. Among these, scientists doing their work in the USA dominate; more than 40 percent of the total. In Physics and Physiology or Medicine the figures are close to 50 percent, whereas in Chemistry it is about 36 per cent. The figures for Prize in different disciplines given to scientists from Great Britain and Germany are similar, however with a clear dominance for the former country in Physics and in Physiology or Medicine. If the nationality representation is analyzed for consecutive 25 years time periods it becomes apparent that the good position for Germany predominantly is a pre-World War Two phenomenon, whereas the USA, since that war, has taken an exceptional lead. During the last 50 years more than 70 per cent of all prizes in natural sciences have gone to the USA. One interesting question is if this country can retain its dominance of global science in the future.

The awardee and the prize

Nobel Prize recipients receive a large sum of money. However the absolute value of the Prize has varied markedly. It had its lowest relative value immediately after the first World War, 1919, only 28 percent. During the last decade the prize has recovered its value. With increasing yearly increments it surpasses now the original value. The present value is about one million dollars. However, as already emphasized, it is not the money that gives the Prize its prestige. To receive a Nobel

Prize is an unmatched honour which brings an unprecedented respect and recognition from colleagues. This fact is further accentuated by the fact that, as was mentioned, on one hand the number of scientists in the world is increasing rapidly and on the other hand there is only a single, or at most two, Nobel Prizes in a field each year. In fact Nobel laureates acquire, in addition to inter-scientific recognition, prestige to make authoritative statements also in matters outside their own field, a condition to be used with wise caution. The Prize is also a recognition of a particular field of science and may enhance advances in this field.

What can we learn from the condition of making discovery rewarded with Nobel Prizes

Creativity in both the science and the arts is an enigmatic phenomenon. May be it is inherent in its nature that it can not be induced, projected or conjectured. Still, we want to understand how we can further creativity and an endless number of books have been published on this theme. The Nobel Foundation is planning to establish a Nobel museum in Stockholm. The first exhibition will open in 2001 and will be housed in temporary localities. The theme of the exhibition will be "Cultures of Creativity: Individuals and Milieus". The main parts of the exhibition will be the following: individual creativity, creative milieus, the Nobel system, Alfred Nobel and his time, timeline, the Nobel Laureates 1901-2001 (samples only).

It is truistic to note that it is unique individuals that contribute to the advance of science. The exodus of scientists from Europe to the United States, in particular Jews from Germany and other European countries, in connection with the Second World War, was a very important factor in the development of the hegemony in science of the latter country. But there are also other factors. Resources help, but more important is an intellectual density created by aggregation of minds and a complete freedom of these minds to exchange ideas. It is striking that milieus that have spawned a large number of Nobel Laureates, like the Rockefeller University (former Institute) and California Institute of Technology, are characterised by a loose organisational structure with emphasis on research groups and their leaders. The intellectual and personal leadership is exceedingly important. A large percentage of Nobel Laureates have worked in laboratories of other Laureates. In milieus of non-dogmatic nature and with non-authoritarian characteristics unexpected things can happen if the right minds are present. They have to be prepared to grasp the unexpected opportunity. Serendipitous events have many times changed the course of science.

What would Alfred Nobel have thought about the global interest for his prizes?

The answer to this question is probably that he would have been very surprised. His intention to provide a long-lasting scholarship for talented young scientists has not materialised. Instead his prizes have evolved to acquire global

visibility. They truly have marked the amazing advance of sciences during the 20th century and will continue to do so in the 21th and they have made science visible to the society at large. Their role may take on increasing importance as we move into societies with an ever increasing dependence on the advance of science. This is a development which sometimes scares people and spurns paradoxical reactions against science. We can take advantage of the Nobel Prizes as a means both to reveal that the lifestyle of scientists can be uniquely rewarding — they can learn amazing things — and that there are often unexpected applications of new knowledge which change the way we lead our life. To this should be added the fact that new unravelled knowledge helps us also to resolve our personal existential problems.

The Royal Swedish Academy of Sciences has commemorated Alfred Nobel with two medals, one already in 1902 but the other in 1996, one hundred years after his death. This posterior attention is certainly well deserved. But the scientific community has also honoured him by naming one of the unstable elements after him, Nobelium. In summary I think he would have enjoyed learning that his will has had such a remarkable impact during a whole century. May be this serious man would have ventured a faint smile of satisfaction.