How Robert A. Millikan Got the Physics Nobel Prize

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ABSTRACT: In 1923, R.A. Millikan was awarded the Nobel Prize in Physics for his work on the elementary charge of electricity and on the photoelectric effect. Recently, historical research had a focus on Millikan's publication practice, as well as on the role of his assistant, Harvey Fletcher. Several studies have raised doubts on whether Millikan can actually be taken as a role model for scientific practice; however, what has not been discussed yet is the question of how the Nobel Committee came to their decision to award Millikan's work. Based on archival material from the Nobel Committee, this paper discusses the nomination procedure, as well as the evaluation process of Millikan's work.

KEYWORDS: Millikan, Nobel Prize, nomination, Nobel Committee.

Introduction

On November 13, 1923, the Royal Swedish Academy of Sciences announced Robert A. Millikan to be the Nobel Laureate in Physics for that year.[1] The aim of this paper is to illustrate the process that led to this announcement. In doing so, our concern is neither the scientific work of Millikan nor the general discussion of his work.[2] Instead, we will take a closer look at what went on in Stockholm with the Nobel Committee. In our examination of this process we will first discuss some general aspects of the procedure by which the Nobel Prize is awarded. In the second part, we discuss the nomination procedure with respect to Millikan. In the third part of this paper, we discuss the nomination, as well as the decision process for the year 1923. Our aim is to show what

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factors may have influenced the decision to award this honor to Millikan.

Setting the Stage

Alfred Bernhard Nobel was a scientist and a successful businessman. By employing his skill as an industrialist and by patenting his numerous inventions he became one of the wealthiest men in the world. When Nobel died in Italy on December 10, 1896, the Nobel Foundation was established under the terms of his second will, drawn up on November 27, 1895. In part it reads as follows: "The said interest shall be divided into five equal parts, which shall be apportioned as follows: one part to the person who shall have made the most important discovery or invention within the field of physics" (Fant, 1995, p. 441). The other parts, in addition to the Nobel Peace Prize, were appointed to chemistry, physiology or medicine, and literature.

The Nobel Prize in Physics is awarded by the Swedish Academy of Sciences in Stockholm. Initially, not all its members are involved in the decision-making process. According to Section Six of the statutes of the Nobel foundation, "the prize-awarding body shall appoint a 'Nobel Committee,' consisting of three, four or five persons, to give their opinion in the matter of the award of prizes" (Statutes of the Nobel Foundation – SNF, 1995, p. 3). According to Section Two of the special regulations for the award by the Royal Academy of Sciences, the Nobel Committees for Physics and Chemistry shall however consist of five members each (SNF – Special regulations, 1994, p. 9), all of whom shall be elected by the Academy. The members of the Committee were elected for a period of three years and could be re-elected. Consequently, some of the members remained on the Committee for more than 20 years, as, for example, Svante Arrhenius, who was a member in the Physics Committee from 1900 until his death in 1927, and Manne Siegbahn, who served on the same Committee from 1923 to 1962. The Committee's members are prominent scientists from Sweden. For the first half of the 20th century,[3] Uppsala University and Stockholm Högskola, particularly, dominated this Committee.

Each year, the nomination procedure begins during the month of September, with the Nobel Committee sending out invitations to persons considered to be competent to put forward proposals.

The special regulations for the prizes of the Academy of Science provide for two broad categories of nominators: those with permanent nominating rights and those invited to submit proposals for the prizes of a given year. Permanent entitlement belonged to Swedish and foreign members of the Royal Academy of Sciences, members of the Nobel committees for physics and chemistry, previous winners of a Nobel prize in physics or chemistry, and permanent and acting professors of physics and chemistry at universities and higher schools in Sweden and other Nordic countries that existed in 1900 (Crawford, Heilbron, & Ulrich, 1987, p. 1). The category of ad hoc nominators comprised of chair-holders in physics and chemistry at six or more foreign universities, selected by the Academy of Sciences to ensure a wide geographical representation, and an unspecified number of scientists individually invited to nominate.

Every nominator can propose several researchers for different achievements, and the proposals have to reach the Committee before January 31st of the year for which the prize was proposed. All nomination letters that arrive too late are not considered but kept for the following year.

In the following months, the Committee prepares a general report which includes the reviews of all nominated candidates. Some general rules are applied, for example, the exclusion of self-nominations and nominations of deceased scientists. Short general reports are prepared on the work of all the nominated scientists, and detailed special reports are prepared for those candidates the Committee considers to be deserving of the Nobel Prize. Finally, the Committee proposes the names of prize-deserving candidates to the Academy and submits the respective general and special reports for each selected nominee.

The proposal is discussed by the physics class of the Academy, which consists of 25 members. Before the Academy makes the final decision, the physics class has to comment on each of the Committee's recommendations. It communicates its opinion and decision about the selection of the Nobel Laureate to the entire Academy. The Academy makes the final decision before mid-November. If there is a disagreement between the proposals of the Committee and the opinion of the Academy, the latter can overrule the Committee's proposal. According to the bylaws (Section 10) of the Nobel Foundation, the discussion and decisions are not be included in the record or divulged in any way (SNF, 1995, p. 5). In contrast to the discussions of the Academy, the initial nomination letters and the reports of the Committee, as well as its proposal, are documented and become available to researchers after 50 years. Consequently we know for example, that in 1908 Max Planck was recommended by the Committee, but the Prize was awarded to a Franco-Luxembourgish physicist, Gabriel Lippmann. Likewise in 1912, Kamerlingh-Onnes was recommended, yet Gustaf Dalén was announced to receive the Physics Nobel Prize (Küppers, Weingart, & Ulzika, 1982, p. 84).

In case no suitable candidate is found for a particular year, the prize will be reserved and can be awarded a year later (Crawford et al., 1987, p. 68). The Prize for the year 1918, for example, was reserved and awarded to Max Planck in 1919.

Rehearsals

On November 13, 1923, the Royal Swedish Academy of Sciences announced Millikan as the recipient of the Nobel Prize Laureate in Physics,[4] in recognition of "his work on the elementary charge of electricity and on the photoelectric effect."[5] Millikan was known to the Committee long before this time, having been part of what may be called the *nobel population* and having nominated Max Planck for the Nobel Prize in 1913 (Crawford, 2002), while holding a chair of physics at an invited university. Millikan, himself, received a nomination – his first – in 1916 from J.B. Clark.[6] Not a physicist, Clark consulted with colleagues, who suggested two researchers. As a consequence Clark's nomination letter reads as follows:

> It is the judgment of those whom I have consulted that two men in this country have made such discoveries. Of these, the first is Professor R.A. Millikan, of the University of Chicago, whose recent contribution to science has consisted in the isolation of an ion and of making precision measurement of its charge. The other is Dr. Irving Langmuir of the General Electric Company … who has made highly fruitful studies of thermionic currents and the phenomena of passage of electricity through highly evacuated space.[7]

The related general report of the Nobel Committee however, stated that Millikan's work had not achieved the required level to be rewarded with the Nobel Prize.[8] This is particularly remarkable as, in that year, not a single nominated candidate seemed to have deserved the prize.

Two years later, Millikan was nominated for the 1918 Physics Nobel Prize by eight different American scientists. H. Crew[9] nominated him "for his well known research on the electronic charge and photo-electric effect, summarized in his volume, *The Electron* (Millikan, 1917)"[10] should be noted that Crew proposed four scientists and placed Millikan as the third nominee.[11] E.B. Frost[12] wrote to the Nobel Committee stating that he passed over the names of Max Planck and Johannes Stark because they might have received the yet-unannounced reserved prize. Instead, he nominated Charles Fabry from France, adding that if Fabry were already considered for the Nobel Prize, then he was nominating Millikan "for his isolation of the ion by the balanced-drop method, and the determination of e, as fully described in Millikan's book entitled *The Electron, Its Isolation and Measurement and the Determination of Some of Its Properties*, Chicago, 1917."[13] Millikan's third supporter was T.W. Richards,[14] who referred Millikan's paper, "A New Determination of e, N, and Related Constant."[15] Richards held the opinion that "this paper seems to me to be one of the most important which I have read for a long time. It is the climax of a long and careful study of the magnitude of the unit of charge of electricity (the electron)."[16] G.E. Hale[17] wrote a short letter on December 3, 1917, nominating Millikan for his work "on the electron and related subjects." C.R. van Hise[18] supplemented the statement of the members of the National Academy of Sciences[19] as follows: "We consider him as already second to no man in physics in the United States."[20] W.W. Campbell[21] sent another nomination that was seconded by the Nobel Laureate A.A. Michelson.[22] Campbell nominated Millikan for his "investigations in Radiation and Atomic Structure."[23] Finally, H.F. Osborn[24] pointed out that Millikan "has been working with ardor and real genius."[25]

Since only Frost's and Crew's letters reached Stockholm in time, the others were considered by the Committee for the following year, 1919.[26] The Committee's report of 1918 discusses the achievements of the nominated physicists W. Crookes, C.T.R. Wilson, and R.A. Millikan.[27] It stated that Crooke's work belonged to an era that lay too far in the past to be awarded with the Nobel Prize. Though the work of Wilson was considered honorable, it did not have the impact that was required by Section Five of the statutes of the Nobel Foundation.[28] The same held true for the works on electricity by Millikan. As a result, the prize for 1918 was not awarded but, instead, reserved for the next year.

In 1919, C.R. van Hise and H.F. Osborn repeated their belated nominations of the previous year.[29] Osborn raised another reason why Millikan should receive the Nobel Prize:

> The Members of your Committee are well aware of the ingenious, untiring and highly successful researches of Doctor Millikan upon the nature of the electron .... They are probably not aware, however, that he was among the first of the Members of the National Academy of Sciences to offer his entire service to the Government, that he suspended all his work, became a Member of the Council of National Research, and then Chairman of the Council, which has been highly successful in

> marshaling and coordinating all the scientific and technical ability of the United States in the cause of liberty and enduring peace.[30]

The Committee's report for 1919 admitted Millikan's measurements were made very diligently and with a subtle and sharp-witted method. Though the Committee did not deny that his research had to be esteemed as being exceptionally worthy, the value of his achievements should not be esteemed equivalent to the work that was awarded by the Committee that year.[31] The Committee awarded the 1919 Nobel Prize in physics to Johannes Stark and the reserved prize from 1918 to Max Planck.

Osborn then proposed Millikan for the 1920 prize, referring again to his work, *The Electron*.[32] Likewise, Richards renewed his previous suggestion and nominated Millikan "on account of his remarkable research on the Electrical Quantity of the Electron."[33]

The Committee's report stated that Millikan's researches were of exorbitant interest and the Committee commissioned Arrhenius to compile a profile of his expertise.[34] This can be taken as an indication that the Committee short-listed Millikan for the first time.

Arrhenius' detailed document, entitled "Millikan's work on the fundamental charge,"[35] focuses mainly on Millikan's publication, *The Electron*, and the experiments related to that publication. Toward the end of his manuscript, Arrhenius also refers to Millikan's criticism of Ehrenhaft's work, as well as to Millikan's experiments on the photoelectric effect.[36] In particular, Arrhenius emphasizes Millikan's experimental abilities and appraises him as an excellent physicist, who could be recommended for the Nobel Prize.

Unfortunately for Millikan, Arrhenius' opinion differed from the one of the Committee. The Committee's report admits that Millikan's research was conducted with the highest precision and the implementation of sharp-witted methods. Moreover, it yields the conclusion that electricity has an atomistic nature by stating that Millikan's research gives the up-to-then best measurement of the smallest occurring portion of electricity, which turned out to be identical to the amount of charge that one electron carries. The Committee's report also points out that Ehrenhaft, in Vienna, examined electrical charges of ultramicroscopic particles and came to different conclusions, namely, that electricity could be found in even smaller portions. Although most physicists had the same opinion as Millikan, the Committee concluded that it was not willing to recommend him for the award.[37] The Committee's position becomes more interesting when it considers that Ehrenhaft was also a member of the "Nobel population," having been invited as a nominator for the 1916 Prize adjudication. The Committee granted the 1920 Nobel Prize for physics to Charles Edouard Guillaume.

The next year, Osborn nominated Millikan once more, as in the years before, but additionally praised Millikan's research in the ultra-violet band that had to be estimated "as a contribution of the first importance."[38] The Committee asked Arrhenius to complement his report on Millikan,[39] who argued in favor of Millikan stating that his results had been confirmed, while Ehrenhaft's peculiar results had been nullified.[40]

The Committee admitted, in its report, that Arrhenius' expert report clarified Ehrenhaft's contradictory results and that Millikan's results seemed to be undisputed at that moment; however, the prize could not be awarded until more experience about the relevance would be gained. Because no other physicist's work appeared to be prize-worthy, the Physics Nobel Prize was not awarded at all.

For the Nobel Prize of 1922, four American scientists nominated Millikan: E.B. Frost, G.E. Hale, T.W. Richards, and C.D. Walcott.[41] Frost referred to Millikan's isolation of the electron by the oil-drop method and the extension of the ultra-violet spectrum,[42] yet Millikan was not his only nominee, for Frost also lauded C. Fabry for his various achievements in spectroscopy, such as his study of the solar spectrum and his invention of the micro-photometer. Richards nominated Millikan, without giving any particular reasons, but also commended F.W. Aston for his work on the isotopes of elements.[43]

Walcott nominated Millikan for his work on the ionic charges that had led to the determination of fundamental constants with great accuracy, but he also nominated Hale, Aston, and Coolidge, even though he admitted the difficulties of these recommendations, as he knew the work of the latter three were older, placing his nominations in contravention to the rules of the Nobel Foundation.[44] Under these circumstances, he also proposed C.G. Abbot for his recent work on solar radiation and two observations stations that Abbot had established in the United States and Chile.[45]

Hale nominated Millikan, mentioning a long list of his achievements, such as the isolation and measurement of the electron charge, the photo-electric determination of Planck's h, the exact value of e, N, and related constants, Brownian movement in gases, and the extension of the ultra-violet spectrum, and included a copy of *The Electron* in his submission to the Committee.[46]

As in the two years before, Arrhenius compiled a further-expanded expert report. He stated that Millikan's achievement concerning the electron had been nearly unaltered since the year before. This expert report concluded that by judging Millikan's own statements, his actual research is not finished.[47]

The Committee followed Arrhenius' expert report and pointed out, in its own report, that Millikan's valuable work on the elementary charge and the photoelectric effect deserved merit. Moreover, Millikan had recently carried out experiments on the spectral lines in the far ultraviolet spectrum. Even though Millikan was considered to be among the most important experimental researchers, the Committee concluded that his work had to stand behind that of other researchers.[48] In 1922, the Nobel Prize for that year, in physics, was awarded to Niels Bohr, and the reserved 1921 prize was awarded to Albert Einstein. Millikan had to wait for another year.

To summarize, it could be argued that Millikan's status within the Nobel Committee improved significantly and he was nominated regularly. His nominators, however, were all Americans even though his researches were also well known in Europe.[49] Two nominators, Osborn and Richards, had proposed Millikan three times, and several nominators played – like Millikan – an important role in the AAAS. Meanwhile, Millikan's status in the Committee had improved, and Arrhenius had prepared special reports for the last three years. Like Millikan's nominators, Arrhenius stressed in his reports, particularly, the experiments on the determination of the elementary charge, although other researches of Millikan were also mentioned. The Committee had always come to the conclusion that even though Millikan was among the most eminent experimentalists, his contributions were not, as yet, sufficient to be awarded with the Nobel Prize.

On Stage – At Last

In 1923, things were slightly different from the years before. Contrary to the preceding years, not a single American nominated Millikan. According to the documentation of the Nobel Foundation, it was only the Swiss Meyer[50] who nominated Millikan. Looking at the nominations, it may seem somewhat surprising that Millikan was awarded the prize in that year, especially as Millikan was, by far, not the only one who had been nominated. Therefore, it is necessary to take a closer look at the report that the Committee prepared for the Royal Academy of Sciences. According to this report, 19 nominators proposed 17 different researchers. Additionally, there were another six nominations for 1922 which were belated and had therefore not come into consideration the previous year. Among these nominations were several that had to be rejected for formal reasons. Belated nominees included Bohr, together with Einstein, and Einstein, together with Lorentz – all of whom had already received the Nobel Prize in physics. Another such nominee was Soddy, who had also already received a Nobel Prize in chemistry for his discovery of isotopes. Ostwald had been nominated twice – for 1922 and 1923 – and unfortunately as the nominator was the nominee, these nominations therefore were to be excluded, according to the bylaws of the Nobel Foundation.[51] Eötvös[52] had passed away in 1919, so that nomination also had to be rejected.

Two other nominations that were not taken into consideration seem to be more interesting. One of these is Siegbahn's, who had been nominated by Chwolson;[53] however Siegbahn had requested at an early stage of the procedure, that this nomination should not be taken into consideration for the 1923 award.[54] The second was Arrhenius' nomination of the *Verein Notgemeinschaft der Deutschen Wissenschaft*, an organization that was founded in 1920 and can be taken as the ancestor of the Deutsche Forschungsgemeinschaft.[55] According to the report of the physics commission, this organization had also been nominated in the field of chemistry. As a result, the Academy was asked to decide whether such a nomination was in accordance with the bylaws. In a report dated April 11, 1923, the Academy decided that the *Notgemeinschaft* could be awarded the prize only for achievements already made but not for potential ones. Consequently, its nomination was not considered any further.

According to the report, the majority of valid nominations were related to research in experimental physics, and these are the ones on which we will focus and discuss in detail. Besides Millikan, these include Paschen,[56] together with Sommerfeld,[57] for their work on the fine structure of spectral lines and for the experiments on the Paschen-Back effect: Rutherford, for his scattering experiments, as well as for the detection of a radiation that is more intense than L-rays;[58] and Hale and Deslandres, for experiments with the spectroheliograph.[59] Some researchers that were considered to be theoreticians were also nominated and discussed. These were Sommerfeld, for the fine structure of the spectra and for his contributions to the atomic theory; Bjerknes for his work on electrodynamics and on meteorology;[60] and Franck, for experiments on the interaction between electrons and mercury atoms.[61]

As already mentioned, Millikan was nominated only by Meyer. Thus, it could be questioned why he and none of the others was awarded the Nobel Prize. In order to develop a rationale for the decision of the Committee, we would like to sketch the reasons for not awarding the Prize to one of the other nominees. Looking at the nominations alone, the most promising candidate for the prize was probably Paschen. He was nominated, together with Millikan, by Meyer, but also by the two Nobel Prize winners, Planck and Wien. Moreover, Paschen was placed in first place by Meyer and Millikan only in the second place. Furthermore, like Millikan, Paschen had been nominated previously.

According to the argumentation of the Committee, Paschen's experimental work, however important, had not resulted in significant progress in the sciences. Consequently, the Committee placed Paschen behind Millikan. Like Paschen and Millikan, Hale had also been nominated in previous years for his work with the spectroheliograph, but the Committee came to the conclusion that Deslandres had contributed to the development of these experiments as much as Hale had. When only Hale was nominated in 1923, Carlheim-Gyllensköld suggested a division between Hale and Deslandres and prepared a respective report. Even though it was admitted that their research had opened a new field in physics and had contributed significant findings, their research was declared to be insufficient to award the prize. In case of Rutherford, the Committee noted that they had already awarded Bohr's "services in the investigation of the structure of atoms and of the radiation emanating from them."[62] As Rutherford's work could be seen as a basis for Bohr's, he should not be awarded the prize. With respect to the work on protons, it was considered unclear whether Rutherford's findings were related to his work that had already been awarded a Nobel Prize in chemistry.

In summary, it can be argued that the nomination process of 1923 shows many similarities with respect to the discussion of Millikan's work in previous years. Obviously, the phrases used in the Statutes of the Nobel Foundation, such as the "most significant discovery or invention in the field of physics," are not that sharply defined, but required, and enable an interpretation by the Committee. Taking the report of the Committee literally, it appears that all candidates, except Millikan, had some deficits; however, this image would be an oversimplification. The Committee's report was intended to serve as a basis for the decision of the Academy, yet, as already mentioned, in some cases, the Academy did not follow the recommendation. Consequently, it had to be made in a manner that made it likely for the Academy to follow. Therefore, in order to understand the awarding of Millikan, it is necessary to take a closer look at the detailed report prepared by an individual member of the Committee.

In the case of Millikan, the report was not prepared by Arrhenius but by Siegbahn, who had just become a member of the Committee. In his report, Siegbahn used a different rationale than that used by Arrhenius, with two central aspects. First, he pointed out that Millikan's findings were no longer considered to be insecure – despite Ehrenhaft's work which initially was taken to raise doubts about the validity of Millikan's work. This, however, had no longer been an argument in 1922, allowing Siegbahn to make this point easily. Second, focusing on Millikan's work on the photoelectric effect, he argued that Millikan's findings were interpreted as a description of electricity in terms of an atomic structure, yet only a minor part of the report was devoted to the oil-drop experiment. Actually, this aspect of Millikan's work is the second part which is mentioned in the Nobel Prize announcement that stated that he was awarded the Nobel Prize "for his work on the elementary charge of electricity and on the photoelectric effect."[63] This work placed Millikan in close relation to another Nobel Prize winner who was finally awarded the 1921 Prize – Albert Einstein. As Friedman has shown, the Committee was very hesitant to select theoretical physicists. When Oseen became a member of the Committee in 1922, things started to change. Oseen successfully started a campaign to promote both Einstein and Bohr, and he, "himself, successfully nominated Einstein for the discovery of the law of the photoelectric effect .... And having declared that the law of the photoelectric effect was a fundamental truth of nature, Oseen could argue for Bohr's quantum model of the atom" (Friedman, 2002, p. 35, see also Friedman 2001, p. 135). Oseen's strategy worked: Einstein was announced to be awarded the Nobel Prize for 1921, and Bohr received the Prize for 1922.

Taking this background into consideration, a different image of the reasons for the Committee's awarding the Nobel Prize to Millikan can be developed. Millikan's work on the photoelectric effect was an experimental expansion of the effect that had been crucial for the two Nobel Prizes awarded one year earlier. Consequently, awarding the Prize to him could be taken as an option for justifying these choices once again.[64] Taking this context into consideration, it is therefore, not surprising that Gullstrand, in his presentation speech, made an explicit reference to the photoelectric effect and its significance for the two previously awarded Nobel Prizes:

> Without going into details I will only state that, if this research of Millikan had given a different result, the law of Einstein would have been without value, and the theory of Bohr without support. After Millikan's results both were awarded a Nobel Prize for Physics last year.[65]

The focus of Gullstrand's presentation speech for Millikan, however, was centered on the oil-drop experiment and the notion of an atomic structure of electricity. Yet, this is not necessarily a contradiction of the interpretation we have developed as there can be two reasons why Gullstrand chose this topic in his public speech. On the one hand, Millikan had been nominated for his research on electrons by almost every nominator, and these experiments were considered to be a valuable contribution by the Committee. On the other hand, particularly referring to these experiments, Millikan could be characterized as a researcher who carried out precision measurements. Consequently, Gullstrand pointed out that "the charge of a single ion could be measured in a very large number of cases, and it was determined with an exactitude of one in a thousand." Characterizing his research on the electron like that, Gullstrand described Millikan as a representative of the traditional understanding of physics "that placed precision measurement as the highest goal for their discipline" (Friedman, 2002, p. 34). Therefore, awarding the Nobel Prize to Millikan can be taken as a decision that combined the traditional understanding of what research should be considered to be praiseworthy with the new understanding that included achievements in the field of theoretical physics.

Conclusion

As we have demonstrated, the reasons for Millikan being awarded the Nobel Prize were not simple. Obtaining the award did not only require excellent experimental skills and convincing results; neither was the support of other researchers sufficient for the Committee to recommend him. While these aspects are essential, they are not sufficient for an award. Other requirements are not as rational. As we have shown, political considerations played an important role within the Committee.[66] It is unclear, whether this was a situation peculiar to the early 1920s, a period that was certainly unusual in the history of science field. We have also shown, as Friedman has pointed out in his study, "Quantum Theory and the Nobel Prize," "to understand the 'whys and wherefores' of the Nobel prizes, insight into the committee and its

Swedish context are essential" (Friedman, 2002, p. 38). In this respect, some more research regarding the role of Millikan's Prize appears to be necessary.

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NOTES

1. Private communication, Annika Pontikis, Public Relations Manager *Nobelstiftelsen*, The Nobel Foundation, July 1, 2008.
2. In this respect, our contribution has a different approach than Eshach (2008); yet, we agree with him that stories focusing on scientists receiving the Nobel Prize could be very useful for educational purposes.
3. For list of members and their working period as member of the Committee, see Crawford et al. (1987, p. 6) and Crawford (2002, pp. 9-10). For other case studies on the history of the Nobel Prize, see e.g., Singh & Riess (1998) and Nielsen & Nielsen (2001).
4. Private communication, Annika Pontikis, Public Relations Manager *Nobelstiftelsen*, The Nobel Foundation, July 1, 2008.
5. Retrieved June 25, 2008 from http://nobelprize.org/nobel_prizes/physics/laureates/1923/
6. John Bates Clark (1847-1938) was an American neo-classical economist and first director of the Carnegie Endowment, New York.
7. J.B. Clark to the Nobel Committee, letter dated Nov. 5, 1915.
8. Report of the Nobel Committee, 1916.
9. Henry Crew (1859-1953) was Fayerweather Professor of Physics at Northwestern University, Evanston, Illinois.
10. H. Crew to the Nobel Committee, letter dated Dec. 12, 1917.
11. H. Crew's other candidates were: Hugh L. Callendar (UK), Theodore Lyman (Harvard University, Cambridge, MA), and Alfred Perot (France).
12. Edwin Brant Frost II (1866-1935) was an American astronomer and appointed director at the Yerkes Observatory of the University of Chicago at Williams Bay, Wisconsin.
13. E.B. Frost to the Nobel Committee, letter dated December 13, 1917.
14. Theodore William Richards (1868-1922) was Chairman of the Department of Chemistry at Harvard, appointed Erving Professor of Chemistry, Director of the Wolcott Gibbs Memorial Laboratory (Cambridge, MA) and Nobel laureate for chemistry in 1914 for measuring atomic weights.

15. R.A. Millikan (1917), "A New Determination of *e, N*, and Related Constant," *Philosophical Magazine, 34*, July 1917.
16. T.W. Richards to the Nobel Committee, letter dated January 2, 1918.
17. George Ellery Hale (1868-1938) was Chairman of the Committee on Research in Educational Studies, Member of Executive Committee for the National Research Council, professor at the University of Chicago, and Director of Mt. Wilson Observatory.
18. Charles Richard Van Hise (1857-1918) was professor and President of the University of Wisconsin in Madison.
19. In a letter of December 1, 1917, Benjamin W. Snow, Department of Physics, University of Wisconsin, wrote to Charles R. van Hise and recommended Millikan. About Millikan's scientific achievements he wrote, "The great work which Professor Millikan has accomplished, by a method entirely original with himself, is the determination of the value of e, or the charge of electron. This quantity is at the basis of nearly every piece of modern physical investigation, and is, indeed, the very foundation upon which physical and electrical science of the present day is built. I think perhaps it is the most important and fundamental investigation in physics that has been carried out in this country since the great work of Rowland."
20. C.R van Hise to the Nobel Committee, letter dated December 7, 1917. Van Hise added that Millikan is still a young man and will probably do even more important research.
21. William Wallace Campbell (1862-1938) was an American astronomer and Director of Lick Observatory (University of California).
22. Albert Abraham Michelson (1852-1931) was professor of Physics and the first Head of the Physics Department at the University of Chicago, Nobel Laureate for physics 1907.
23. W.W. Campbell to the Nobel Committee, letter dated December 31, 1917.
24. Henry Fairfield Osborn (1857-1935) was professor of Biology and Zoology at Columbia University and President of the American Museum of Natural History, New York.
25. H.F. Osborn to the Nobel Committee, letter dated January 7, 1917. This letter may have been misdated, as according to the note of the Nobel Institution, the letter arrived on March 11, 1918.
26. See the nominee list in Crawford et al. (1987, p. 76).
27. Report of the Nobel Committee [NC] 1918.
28. The report refers to the Section Five of the statute of the Nobel Foundation, according to which a "work may not be awarded a prize, unless it by experience or expert scrutiny has been found to be of such outstanding importance as is manifestly intended by the will. If none of the works under consideration is found to be of the character here indicated, the prize money shall be reserved until the following year. If, even then, the prize cannot be awarded, the amount shall be added to the main fund" (SNF, 1995, S. 5).

29. C.R. van Hise to the Nobel Committee, letter dated November 12, 1918. E.H. Osborn to the Nobel Committee, letter (undated). It reached the Committee on December 30, 1918.
30. E.H. Osborn to the Nobel Committee, letter (undated).
31. Report of the Nobel Committee, 1919.
32. Osborn to the Nobel Committee, letter dated November 7, 1919. He also proposed Robert Williams Wood (1868-1955, professor of experimental physics at Johns Hopkins University) and Carl Barus (1868-1935, Brown University).
33. T.W. Richards to the Nobel Committee, letter dated December 8, 1919.
34. Report of the Nobel Committee, 1920.
35. This document is dated August 17, 1920.
36. In this respect, Arrhenius stresses that Millikan's work is a striking proof of the applicability of the quantum theory by his computing a value of Planck's constant nearly concordantly to Planck's own concluded value. In doing so, Arrhenius relates Millikan's precision measurements to a work that had just been awarded with the Nobel Prize.
37. Report of the Nobel Committee, 1920.
38. F.H. Osborn to the Nobel Committee, letter dated November 24, 1920.
39. Report of the Nobel Committee, 1921.
40. Expert Report July 11, 1921.
41. Charles Doolittle Walcott (1850-1927), professor of palaeontology, co-founder of the Carnegie Institution, and Secretary of the Smithsonian Institution.
42. E.B. Frost to the Nobel Committee, letter dated December 27, 1921, referring to R.A. Millikan's "The Extension of the Ultra-Violet Spectrum" in *Astrophysical Journal*, *52*, p. 47, 1920.
43. T.W. Richard to the Nobel Committee, letter dated January 5, 1921.
44. According to the Section Two of the bylaws, "The provision in the will that the annual award of Prizes shall be intended for works during the preceding year" should be understood in the sense that the awards shall be made for the most recent achievements in the fields of culture referred to in the will and for older works only if their significance has not become apparent until recently" (SNF, 1995, S. 2).
45. C.D. Walcott to the Nobel Committee, letter dated January 9, 1922.
46. G.E. Hale to the Nobel Committee, letter dated October 18, 1921.
47. Expert Report, August 15, 1922.
48. Report of the Nobel Committee, 1922.
49. His monograph, *The Electron*, was translated into German (Millikan & Stöckl, 1922), and his work was referred to in textbooks (see Parlow, 2006; Niaz & Rodriguez, 2004).
50. Edgar Meyer (1879-1960) was professor of experimental physics at the University of Zurich since 1916. He was known due to his research on

radioactive decay and on ultraviolet radiation (Bömmel, 1994 in DNB 331f.).

51. Actually, Wilhelm Ostwald (1853-1932) had already received the chemistry Nobel Prize in 1909; consequently, he was able to submit a nomination each year.

52. Lorand Eötvös (1848-1919) is best known for his experiments with a torsion balance that demonstrated the similarity of gravitational and inertial mass.

53. Orest Danilowitsch Chwolson (1852-1934) was physics professor at St. Petersburg University and is best known for his influential textbook (Chwolson & Schmidt, 1902).

54. Siegbahn was awarded the reserved Prize for 1924 in 1925.

55. On the early history of the *Notgemeinschaft* see Marsch (1994).

56. Friedrich Paschen (1865-1947) is well-known for his work on spectroscopy and became president of the Physikalisch-Technische Reichsanstalt from 1924 until 1933.

57. Arnold Sommerfeld (1868-1951) was among the leading theoretical physicists; however, he was never awarded the Nobel Prize (on Sommerfeld see Eckert, 1993).

58. What was called L-rays in 1923 turned out to be protons that were emitted in the radioactive decay of artificial radioactive nuclides. At that point Rutherford was already a Nobel Laureate in chemistry.

59. Henri-Alexandre Deslandres (1853-1948) was director of the observatories in Paris and Meudon and received the Gold Medal of the Royal Astronomical Society, the Henry Draper Medal of the National Academy of Sciences, and the Bruce Medal of the ASP.

60. Vilhelm Friman Koren Bjerknes (1862-1951) was founder of the geophysical institute at the University of Bergen and is best known for his work in meteorology that focused on the foundations of weather forecasts (see Friedman, 1989).

61. Franck was, together with Gustav Hertz, awarded the Nobel Prize for this work two years later.

62. Retrieved October 15, 2008 from
http://nobelPrize.org/nobel_Prizes/physics/laureates/1922/index.html

63. Retrieved June 15, 2008 from
http://nobelPrize.org/nobel_Prizes/physics/laureates/1923/

64. In this context, it appears remarkable that Elzinga (2006, p. 161) suggests “Gullstrand’s resistance [to awarding Einstein the Nobel Prize] was probably weakened with a promise that Millikan might be awarded a Prize once Einstein and Bohr had been recognized.” Gullstrand, A., Presentation Speech … on December 10, 1923.

65.Retrieved June 29, 2008 from
http://nobelPrize.org/nobel_Prizes/physics/laureates/1923/press.html

66 This also shows that Fletcher's claim that the first publication on the charge determination won Millikan the Nobel Prize is an oversimplification (Fletcher, 1982; see also Klassen, 2007).

67. The Swedish Government decreed on the April 27, 1995, the Statutes of the Nobel Foundation that were approved by the Crown on June 29, 1900 (abbreviated as SNF, 1995). The Statutes of June 29, 1973, containing special regulations concerning the award by the Royal Academy of Sciences of Prizes from the Nobel Foundation etc. was decreed by the Government on April 7, 1994 (abbreviated as SNF, Special regulations, 1994). The information quoted in this section is taken from these documents.

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