From Applied to Pure Chemistry

A.I. Virtanen's Race for His Wartime Nobel Prize

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In 1945 A.I. Virtanen received the first and so far the only Nobel prize in science given to a Finn.[1] Virtanen (1895-1973), at the time Professor of biochemistry at the University of Helsinki, was awarded the prize in chemistry "for his research and inventions in agricultural and nutrition chemistry, especially for his fodder preservation method." His main invention was AIV-fodder, a silage method, identified by his initials, which prevented the nutritional decomposition of fresh hay by lowering the acidity level quickly to pH 3-4 using mineral acids.

The Royal Swedish Academy of Sciences releases the documents of Nobel prizes to scholars after a fifty-year-delay. Now that the documents of 1945 rewardings are available new light can be shed on Virtanen's prize.

Matti Heikonen (1996: 164), Virtanen's biographer, has already studied the Nobel archives and found no surprises. The only new thing the Nobel archives could tell him was that Virtanen was nominated since 1933 and "from the beginning he was taken seriously", and "in 1945 he was much more superior than it has been thought so far". Knowing who were Virtanen's competitors, however, is not sufficient to explain why he was rewarded. The documents of the 1945 decision will raise more fundamental questions if they are interpreted in their historical context, as part of the decision-making tradition of the Nobel committee and in the light of Virtanen's own scientific career.

Virtanen was rewarded at the end of the Second World War when Finland had fought and lost two wars against the Soviet Union; the Winter War in 1939-1940 and the Continuation War of 1941-1944. Although not occupied by Soviet troops, the separate peace agreement, signed in September 1944, had a decisive effect on Finnish home affairs by dissolving organizations considered as "fascist", and legalizing the Finnish Communist Party.

Some peculiarities in the way Virtanen was awarded the prize suggest that uncommon wartime circumstances

may have played a role. Virtanen had almost no international support and was nominated almost entirely by compatriots.[2] In addition to the AIV fodder preservation method the Nobel Committee for Chemistry took into consideration Virtanen's theory on the biological fixation of atmospheric nitrogen which, shortly after the rewarding ceremonies, started to lose ground and was later shown to be false (Nobel Protokoll, 1945; Heikonen, 1993: 160-162, 173-174, 234).[3]

In addition to the possible effect of wartime circumstances, Virtanen's prize also highlights boundaries between applied and pure chemistry. During his career Virtanen moved from applied chemistry to more pure fields of research. After having invented the AIV fodder preservation method in the late 1920's, he started to examine the more general problem of nitrogen fixation in leguminous plants. The purposefulness of Virtanen's reorientation together with the way the Nobel Committee for Chemistry evaluated his divergent contributions raise the question how applied and pure chemistry were appreciated by the Nobel committee and by the chemistry community in general.

Nomination Actions

The Nobel award process starts with the nomination of candidates. Swedish and foreign members of the Royal Swedish Academy of Sciences, members of the Nobel Committee for Chemistry, Nobel laureates together with professors in chemistry from Nordic and specially invited universities have the right to propose candidates. The nominations must be made before February 1 of the year in which the prize is to be awarded.

Virtanen was nominated regularly from 1933 onwards, and with only one exception all the nominators were Finnish professors who actively used their special right as representatives of Nordic universities to nominate Nobel candidates. Finns were used to take part in Nobel activities. In 1930's they had nominated several non-compatriot candidates but since the war had broken out they stuck with their own candidates.[4] The tendency was not unique in the history of Nobel prizes (Crawford, 1992).

Niilo Toivonen, professor at the University of Helsinki, and Oskari Routala, professor at the University of Technology, started in 1933. They kept on nominating their colleague regularly year by year until Routala's death in 1937 after which Toivonen alone nominated Virtanen until 1941.[5] Routala and Toivonen nominated Virtanen foremost for the AIV fodder preservation method and secondly for his studies on nitrogen fixation (Nobel Protokoll, 1933).

In 1933 and 1934, however, Routala and Toivonen had nominated Virtanen both alone and with Søren Sørensen, the inventor of the notion of pH in 1909. Their first nomination letter proposing solely Virtanen was signed on the 16th of January 1933. Two weeks later they sent an "alternative" nomination letter where they nominated Virtanen and Sørensen together, Sørensen for the notion of pH, "showing the importance of hydrogen-ion concentration in biochemical processes", and Virtanen for his "especially in practical terms important works" on biological nitrogen fixation and butter and cheese production (Nobel Protokoll, 1933, 1934).

In 1941 Hans von Euler-Chelpin, a German-born Swedish biochemist and

a member of the Nobel Committee for Chemistry, joined Toivonen nominating Virtanen and continued to do so until the award in 1945. Von Euler had been Virtanen's teacher in the early 1920's when Virtanen was staying in his laboratory at the University of Stockholm (*Högskolan*). Since those days they were in close correspondence and von Euler followed the development of the career of his former student (Nobel Protokoll, 1941-1945; Heikonen, 1990: 41-44).

In 1942, during the Continuation War, Finns mobilized with as many as seven professors nominating, but this time their candidate was Gustav Komppa, a well-known terpene chemist and a professor at the University of Technology in Helsinki, leaving Virtanen without Finnish support. The majority of this group, nominated Komppa in the following two years, but without success.[6] The Nobel prizes were reserved in 1940-43 although invitations for nominations were sent out. In 1944, when the end of the war looked likely, the Academy of Sciences awarded the 1943 prize and in the following year the 1944 and 1945 prizes.

The next turn in Virtanen's nominating process took place in 1945, when five Finns again moved to support Virtanen.[7] This group was quite different from the group that supported Komppa in 1942.

The group behind Komppa was not only more numerous but more representative. Among Virtanen's supporters there were no Swedish-speaking professors like there were behind Komppa. Virtanen's nominators were all members of the Society of Finnish Chemists (*Suomalaisten kemistien seura*) which had been found in opposition to the corresponding Swedish-speaking society, the Finnish Chemical Society (*Finska Kemist Samfundet*) (see Suomalaisten kemistien seuran jäsenet). During the early decades of 20th century Finnish academic life experienced so-called 'Language dispute' when Finnish-speaking majority enforced its positions at the expense of the Swedish-speaking establishment.

The institutional background of the nominators of Virtanen was narrower than Komppa's. Virtanen's nominators all came from the University of Helsinki. The professors of the University of Technology were totally missing from Virtanen's list of nominators in 1945. Both John Palmén and Yrjö Kauko kept on nominating Komppa, a professor of their own university (Nobel Protokoll, 1945).

Both Virtanen and Komppa were representative figures for a national endeavor in their strong patriotism, but their institutional background was different. They were both active members of scientific organizations like the Society of Finnish Chemists (*Suomalaisten kemistien seura*) and the Finnish Academy of Sciences (*Suomalainen Tiedeakatemia*), lingual organizations working since 1919 and 1907, respectively, to improve the status of Finnish language (Enkvist, 1972: 121-127). But while Komppa spent his whole career at the University of Technology, Virtanen moved from an industrial laboratory to an academic institution. His career started in the laboratory of Valio, the central association of the Finnish cooperative dairies. Here he made his most important inventions, the AIV fodder and the AIV butter preservation salt, when he was meeting the problems of cheese manufacturing at Valio in late 1920's. In 1931 he was called to the newly created chair of biochemistry at the Uni-

versity of Technology. Virtanen may not have felt comfortable there and seemed to had been glad when he was called to the newly established chair of biochemistry at the University of Helsinki in 1939 (Heikonen, 1990: 65-72, 77-101; 1993: 77-80).

The group behind Virtanen appears to have been more politically orientated. Pentti Eskola was notorious for his pro-German policy and Pauli Tuorila was a parliamentarian of the Patriotic People's Movement (*Isänmaallinen Kansanliike*) an anticommunist extreme-right party in Finland in 1930's. Eskola had a professorship not in chemistry but in geology and mineralogy (Helsingin yliopisto, 1977).

The professors nominating Komppa did not form a group. Komppa was nominated in six letters which all presented different reasons why Komppa's work in synthesis should be regarded as worthy of a Nobel prize. Wartime conditions meant that the justifications often went beyond chemistry. It was recalled that Komppa had done his work in a "little land with relatively meager resources" and "with real Finnish *sisu* (guts)", that he had done his major work "during the period (1903-1908) when several famous chemists of the turn of the century were waiting for their Nobel prizes" and for this reason was left without a prize (Nobel Protokoll, 1942).

Virtanen's nominators acted as a group and the argumentation was strictly scientific. Professor Eskola wrote the nomination letter and others adhered to it first by telegram and later by a letter of confirmation (Nobel Protokoll, 1945). It is striking that the key person was not Niilo Toivonen, Virtanen's and Komppa's faithful nominator since 1933, but Eskola who was new in Nobel activities.

Eskola's nomination letter was well targeted. It referred directly to Alfred Nobel's will and stated that Virtanen's studies "in agricultural and nutrition chemistry" had "benefited mankind". Eskola did not bother to repeat the advantages of the AIV fodder mentioned in the earlier nomination letters but showed instead the progress Virtanen had made in his nitrogen fixation studies. For a geologist and mineralogist Eskola gave a surprisingly accurate account of how the most recent results of other scientists supported Virtanen's nitrogen fixation theory. Thus Eskola was implicitly responding to the criticism Virtanen's theory had met (Nobel Protokoll, 1945).

The political contexts of the nominations of Komppa's and Virtanen's were very different. In 1942, when Komppa was nominated, Finland was fighting successfully alongside Germany against the Soviet Union in the Continuation War 1941-1944 to reconquer territories it had lost in the Winter War 1939-40. In 1942 Finland was seeking political backing from Britain, Sweden and the United States and claimed that the Continuation War was "a separate war", i.e., Finland had its own motives to fight the Soviets.

In 1945 Finland had lost the war and had to get along with the terms of the separate peace agreement with the Soviet Union. Finland was expulsing German troops which caused a disastrous war in Lapland. War indemnities had to be paid to the Soviet Union and more territories, in addition to the ones lost in the Winter War, had to be given up. The leading Finnish politicians were to be

judged as responsible for the war and all Finnish organizations considered as "fascist", like the Patriotic People's Movement, had to be dissolved. A Soviet-lead Allied Control Commission was installed in Helsinki to make sure that the terms of the peace agreement were fulfilled.

The peace agreement with the Soviet Union also had its consequences for the University of Helsinki. The Control Commission demanded that certain professors should be dismissed for their pro-German attitudes. As a result the President of the university had to resign for taking part in recruiting a Finnish SS-unit (J.K. Paasikiven päiväkirjat, I: 107, 156, 161-162, 165, 180). In 1945 the extreme political right had all the reasons to be afraid of loosing their positions. The Finnish professors wanting to protect Finnish institutions probably saw a Nobel prize as a way of getting international recognition and support. They probably had in mind the Nobel prize in literature given to the Finnish author F. E. Sillanpää in 1939, just before the Winter War broke out.

As Nobel laureate, Virtanen openly manifested his anti-Soviet views and caused problems to the Finnish political leadership who was trying to cope with the Control Commission. Already in the Nobel press conference Virtanen made an anti-Soviet statement. Later, as President of the Academy of Finland, he continued to express political views, which the political leadership had described as "dreadfully childish" (Heikonen, 1993: 154-156, 195-200; J.K. Paasikiven päiväkirjat, I: 423, 460).

During the post-war 'Years of Threat' in 1944-48, when it was feared that Finland would be annexed by the Soviet block, science played important social and political roles. The idea to establish the Academy of Finland, a college of ten academicians in different domains of arts and sciences fulfilled in 1948, was seen as a means to combat national inferiority caused by the military defeat. The extreme-left, indeed, strongly opposed the idea maintaining that proponents of the late pro-German policy would be elected to the Academy. The "Fight for the Academy of Finland" that broke out was a fight over the political orientation of post-war Finland. During it, politicians like Urho Kekkonen, the future President of the Republic (1956-1981) and the central figure of the new pro-Soviet foreign policy, unsuccessfully opposed the election of such as candidates Rolf Nevanlinna (the war-time president of the University of Helsinki) to the Academy of Finland (Immonen, 1995: 18-19, 25-27).

Finnish reactions to Virtanen's prize illustrate the social importance of science in post-war Finland. The press saw the award as an important international recognition during a difficult time when the trial against the Finnish wartime political leadership had just begun. The news led to an initiative to honor Virtanen through a mass celebration. Virtanen's anti-Soviet statements in the Nobel press conference, however, frightened the government and the initiative shrunk to a minor celebration (Heikonen, 1993: 150-152, 160).

The Evaluation Process

After having received the nominations, the Nobel Committee for Chemistry starts to evaluate the candidates. The evaluation is based on reports usually written by committee members them-

selves before the September 15. The committee makes a recommendation to the Royal Swedish Academy of Sciences concerning the laureate for that year. The final decision is made by the Academy before November 15 and the award ceremony is held on December 10.

Since Virtanen was nominated each year from 1933 to 1945 (with the exception of 1940) the evaluation process reflects his move from applied chemistry to more theoretical studies. The Nobel committee had to decide how to emphasize the practical fodder preservation method and Virtanen's more recent studies on the mechanism of biological nitrogen fixation. The central figure in the evaluation process was Hans von Euler, who, as a member of the Nobel Committee for Chemistry, wrote most of the evaluation reports on Virtanen's work.

The appreciation of the AIV-fodder preservation method and the theory of nitrogen fixation varied in the course of the years. In his early reports, in 1933 and in 1935, von Euler put the AIV fodder in the first place considering it as Virtanen's "most important" work, which because of "its great practical importance" could be "considered to be worth the Nobel prize" (Nobel Protokoll, 1933).

The importance of nitrogen fixation studies grew during the 1930's when Virtanen made progress in his theory building. By the end of the decade Virtanen had presented his own hydroxylamine theory on the mechanism of nitrogen fixation. According to it aspartic acid, the major nitrogen compound found by Virtanen in the plant soil, was formed in a reaction where oxalacetic acid and hydroxylamine, together with molecular nitrogen forms oxim which in turn gave the l-aspartic acid.[8] In the 1938 report von Euler concentrated on the nitrogen fixation studies, on the basis of which "Virtanen could be considered for an award already now". The 1939 report, written exceptionally by Christian Barthel, professor at the University of Agriculture (*Lantbrukshögskolan*) in Uppsala, gave the priority to nitrogen fixation studies (Nobel Protokoll, 1938, 1939).

During the wartime, however, the importance of the AIV fodder grew again. In 1941, after von Euler himself started to nominate Virtanen, he stated that "now could be the right moment to reward an agrotechnological improvement so important to nutrition". In his 1945 nomination von Euler gave priority to the AIV method, and putting forth Virtanen for his "plant chemical studies especially concerning protein conservation and nitrogen fixation." His two evaluation reports of the same year both mentioned the AIV method in the first place. In 1945 the attention of the Nobel committee was thus clearly on Virtanen's fodder preservation method, and professor Ragnar Nilsson, at the University of Agriculture, was asked to draw up a report especially on the AIV method. Virtanen's Finnish nominators, however, were not sensitive to this change of climate in Stockholm, but kept on stressing the nitrogen fixation studies in their nomination letter (Nobel Protokoll, 1941, 1945).

In addition to the wartime circumstances, the role of AIV fodder might have been emphasized because of the difficulties Virtanen's nitrogen fixation theory had met. In the early 1930's von Euler had not recommended an award because "Virtanen's plant chemical stud-

ies are ... not yet finished to the extent that a final evaluation of their possibly great value could be made" (Nobel Protokoll, 1935). In 1945 the studies were still unfinished and Virtanen's theories had met severe criticism. His foreign colleagues, especially in the United States, had not been able to confirm Virtanen's results. When a scientific controversy broke out, which even extended to *Nature*, Virtanen defended his hydroxylamine theory while the Americans supported ammonia as the intermediate product in the fixation process (Heikonen, 1993: 52-57, 162-163).

Although each of the three evaluators had his own view of Virtanen's studies, none of them cited any of Virtanen's opponents in their reports. Von Euler apparently trusted Virtanen's studies. He gave a solid picture of how Virtanen had made progress in his fixation studies obtaining "strong evidence for the assumption that hydroxylamine is the first nitrogen fixation product in the leguminous plants" (Nobel Protokoll, 1945: von Euler's report on May 14). The trust may have been due to the close contacts he had had with Virtanen since two decades. Nor did Christian Barthel, professor in microbiology at the University of Agriculture (*Lantbrukshögskolan*) in Uppsala, mention the criticism that Virtanen's theory had met. In 1939, when writing his report, Barthel was an adjunct member in the committee becoming a full member in 1945 (Nobel Protokoll, 1945: Ragnar Nilsson's report). According to him the "nitrogen fixation theory has got essential support" although no "direct proof" of hydroxylamine was found (Nobel Protokoll, 1939).

However, Barthel could not have been unaware of the controversies. A colleague in his institute, G. Bjärve, one of Virtanen's opponents, claimed that the nitrogen compounds Virtanen had found were not fixation products but decomposition products of hair roots. Bjärve also conveyed the information that the American researchers had disagreement with Virtanen. In his letter to Virtanen Barthel could only regret the controversy and hoped it would not worsen the relationship of the two institutes (Heikonen, 1993: 50). Barthel had a close relationship to Virtanen who in the early 1920's had stayed in his laboratory where he actually got the idea of controlling biological processes by manipulating the pH level (Heikonen, 1990: 34-36).

Despite the probability that the hydroxylamine theory was correct, Barthel had his doubts about Virtanen's priority to his theory: "Virtanen can not be considered to have the priority to some parts of his reaction chain, because hydroxylamine and oxim have been found before by other researchers" (Nobel Protokoll, 1939).

Barthel was also suspicious of the originality of the AIV fodder. According to him G. Fingerling had developed a fodder preservation method in 1926 using mineral acids to lower the acidity level down to pH 2 which was, however, physiologically too sour for cattle. Thus the AIV method could not be regarded as a "chemical discovery" but perhaps as an "improvement" as stated in the will of Alfred Nobel. Neither was Barthel sure that the connection between the fodder preservation method and the more theoretical nitrogen fixation studies was as strong as Virtanen's Finnish nominators had claimed, thus giving reasons to

doubt that Virtanen's theoretical studies did not originate from the AIV fodder and that they should not be rewarded together (Nobel Protokoll, 1939). Von Euler, however, recognized this connection proposing in 1945 that Virtanen should be rewarded "for his works in the field of agricultural and nutrition chemistry which are connected with the development of his AIV method" (Nobel Protokoll, 1945: von Euler's report on May 14). He also had acknowledged the theoretical value of the AIV fodder previously having written that Virtanen had developed his fodder "on the basis of theoretical reflection" (Nobel Protokoll, 1933).

Ragnar Nilsson, Barthel's successor at the University of Agriculture, invited in 1945 to evaluate the AIV-fodder, was not as suspicious as Barthel. According to Nilsson the fodder could be seen as an "invention" since Virtanen's contribution had been to use precisely the pH level of 3-4 which was physiologically not too sour. Nilsson also recognized the connection between the AIV fodder and Virtanen's studies on biological nitrogen fixation. However, "from a purely scientific point of view the AIV method is not the most valuable part of Virtanen's work and does not stand comparison with his studies on the chemical mechanism of nitrogen fixation". Nilsson left it up to the committee to evaluate these two different parts of Virtanen's studies (Nobel Protokoll, 1945).

As a result, the Nobel Committee for Chemistry ended up by proposing a prize for Virtanen, "for his research and inventions in agricultural and nutrition chemistry, especially for his fodder preservation method". The emphasis lay on the AIV fodder because "its importance from national economic and nutritional physiological points of view ... has proved to be more and more obvious during recent years." However, the committee was not "convinced that the development of the AIV method is Virtanen's most important scientific achievement." "His studies of nitrogen fixation promise to become of even greater importance." Anyhow, like in 1933, despite "great success" the fixation studies "are hardly finished to the extent that their rewarding by a Nobel prize could be recommended." Instead the committee preferred to see theoretical contributions in the fodder preservation method and foresaw that the "theoretical and practical formulation of the AIV method" provides a firm basis for future studies on silage (Nobel Protokoll, 1945).

In the Nobel lecture in Stockholm Virtanen presented his own view on his achievements. He put the main emphasis on the nitrogen fixation studies and waited until the end of his lecture to present the AIV fodder and the AIV butter preservation salt conveying the impression that the practical methods originated from his theoretical studies (Nobel Lectures, 1942-1962: 74-103). Thus Virtanen wanted to see himself foremost as a theoretician and only secondly as applied scientist – although the historical order of these two phases of his career were just the opposite.

Von Euler's version of the award process in his memoirs was that he had "pushed through Virtanen's Nobel prize, against a somewhat doubting Barthel." "It was a great pleasure for me to be able to telegraph the happy news to my friend [Virtanen]", he wrote (von Euler-Chelpin, 1873-1964: 162).

Returning home from Stockholm,

Virtanen had a shock when he was told that his close laboratory assistant had been caught forging results of experiments, which raises doubts that Virtanen's nitrogen fixation theory was based, at least partly, on forged results. Von Euler had estimated that a copublication of Virtanen and his fraudulent assistant was "very important" (Nobel Protokoll, 1945: von Euler's report on May 14). The fraud was only exposed in 1980's by Virtanen's cooperator Henning Karström. Heikonen gives the impression that Virtanen's assistant could not stand the pressure, when Virtanen pushed his staff to get urgently needed proof of his nitrogen fixation theory, but gave Virtanen what he wanted. This incidence together with the latest news about the experiments done in the United States during the war years led Virtanen to merge his own hydroxylamine and the Americans' ammonia theory already in the published version of his Nobel lecture (Heikonen, 1993: 160-163; Karström, 1985: 412; Nobel Lectures, 1942-1962: 82).

The Blessing and the Burden of the AIV Fodder

The alternating emphasis on the AIV fodder and nitrogen fixation studies raises the question how applied and theoretical research was emphasized during the awarding process. Since the history of Nobel prices in sciences has only been studied in part the way Virtanen was awarded can only be compared to the procedure in the early years of Nobel institution, that is 1901-1915 (Crawford, 1984).

The will of Alfred Nobel stressed the experimental nature and practical value of scientific contributions. The will prescribed that a specific "chemical discovery or improvement" should be identified and rewarded – a demand which had caused trouble when the committee had wanted to reward scientists for their life's work. Furthermore, the discoveries and inventions should have "conferred the greatest benefit on mankind ... during the preceding year." As a result in chemistry Nobel's will pointed to the reward of concrete experimental findings, like new elements, at the expense of theoretical achievements (see the will of Alfred Nobel; Crawford, 1984: 158-161, 164-166).

However, the will spoke about "the most important" discoveries. Since the committee members were university professors, the "importance" – as well as the benefit to mankind – was interpreted to mean discoveries of a more general nature that offered possibilities for further studies and thus promoted scientific research. As a result theoretical merits gained more appreciation in the course of the time (Crawford, 1984: 164).

The problem in Virtanen's case was his main contribution. Was it the AIV method which was indisputably of great practical and economical importance but whose scientific and theoretical value was considered to be low, or was it the unproved theory of nitrogen fixation? As a result the committee decided to recommend the prize especially for the AIV method considering that it had been developed "on the basis of purely theoretical work" and could thus offer "a solid basis and starting point" for future studies in the matter of silage.

Concerning the decision-making tradition in the Nobel committee it is noteworthy that in 1945 it was no more con-

sidered a hinder that Virtanen had patented the AIV fodder in several countries. Before the First World War it was presupposed that in addition to the work benefiting mankind the candidate should not have profited personally (Crawford, 1984: 160). When rewarding Otto Wallach in 1910 it was expressively mentioned that Wallach had not patented his inventions but left them for common use (see the presentation speech by the President of the Royal Swedish Academy of Sciences, Nobel Lectures, 1901-1921: 177). In Virtanen's case, the chairman of the Nobel Committee for Chemistry Arne Westgren paid positive attention to the fact that the rewarded invention was copied in Germany and America (Nobel Lectures, 1942-1962: 73). The remark emphasized the general value of the AIV fodder but also touched on Virtanen's misfortune in patent affairs. In Germany a long process of protests and answers had resulted in a decision where a native fodder preservation method was given priority. Virtanen had also failed to receive royalties from the United States (Heikonen, 1993: 23-29, 34-36, 39-40).

The experience of early Nobel science prizes also leads one to ask whether the fact, that Virtanen's prize was the first given for agricultural chemistry (and by 1997 the only one), did contribute to his awarding. In its early years the Nobel committee had tented to favor those fields of chemistry which had not been recognized before (Crawford, 1984: 180). In Virtanen's case this was not, however, an argument, although the wartime food shortage pointed up the importance of nutritive chemistry – more than ever.

Even though Virtanen was rewarded especially for his fodder preservation method the Nobel Committee had recognized the importance of biological nitrogen fixation studies which reinforced his image as a chemist capable of doing theoretical research. In this respect Virtanen's Finnish competitor Gustav Komppa may have appeared as a one-sided experimentalist. Komppa's career consisted only of camphor and terpene synthesis. Even though he had been successful also after his famous camphor synthesis in 1903 the Nobel prizes in this field of chemistry had been awarded Otto Wallach and Leopold Ruzicka (1939) who were both able to generalize their experimental work. Ruzicka had shown the general structure of terpene compounds and was basing his work on Wallach's works (Nobel Lectures, 1901-1921: 175-194; Nobel Lectures 1922-1941: 468-492; Hückel, 1952).

Niilo Toivonen, Komppa's nominator from the University of Helsinki, foresaw the problem with theory and stressed in his nomination letter in 1942 that Komppa's synthesis "had helped to clear up the whole chemistry of alicyclic compounds" and "had even contributed to the quick development of vitamin and hormone chemistry being extremely fruitful in terms of theory and, indirectly, practice as well" (Nobel Protokoll, 1942).

The Nobel Committee was not willing to look for theory in experimental work and preferred theoretical achievements that lead to practical applications. In 1942 the committee stated that the nature of Komppa's work had not changed since 1937 when he was nominated for the first time: "its theoretical value can hardly be compared with his earlier works evaluated by the committee". It found that the work of Komppa "did not represent enough of a breakthrough"

(Nobel Protokoll, 1942).

However, the theoretical value of the AIV fodder preservation method was not evident either. Even among Finnish chemists, Virtanen had opponents who had failed to recognize the merits of his method. They were not prepared to accept that AIV fodder was not just a modern copy of an old traditional conservation method (to store cut hay under a pressure while lactic acid fermentation lowered acidity level and conserved the hay). The traditional method was, however, uncertain and there had been many attempts to enforce natural souring, as noticed in Barthel's evaluation report. The basic idea of AIV fodder was indeed to secure the conservation by lowering the pH level quickly under 4 but not under 3 in order that the hay be still eatable by the cattle (Heikonen, 1993: 31).

The doubts concerning the AIV method came from the applied sciences. Heikonen tells us in his biography that Virtanen had two active opponents at the University of Helsinki, the professor of agricultural chemistry and physics Johannes Valmari, and the professor of animal husbandry Ilmari Poijärvi. They both tried to show that AIV fodder had a negative effect on animal bones. Valmari, who gave a negative report on Virtanen's patent application for the AIV fodder, was in fact the first one to nominate Gustav Komppa in 1937 (Heikonen, 1993: 20; Crawford *et al.*, 1987: 281).[9]

Komppa himself also had doubts about the AIV method. He tried to make fodder himself on his farm by using traditional method and he claimed that the result was as good as Virtanen's. It was, however, "almost manure", the pH level being 5,5 which meant a high decomposition of nutrients (Heikonen, 1993: 41). Komppa's stubborn nominator Yrjö Kauko in 1945, had presented doubts that in practical work on the farms it was difficult to obtain precisely the pH level 3-4 putting the main idea of the AIV fodder into question (see Virtanen's statement on Kauko's application for the professorship in physical chemistry at the University of Helsinki, Matemaattis-luonnontieteellisen osaston pöytäkirjat, 7.10.1943; Kauko's complaint to the chancellor of the university, 2.12.1943).

The unclear relationship between practical method (to store chopped hay in silos) and the theoretical basis (to use the pH level between 3 and 4) could have been the reason for the speculations on the share of Virtanen's close and truthful assistant Dr. Henning Karström in the work rewarded. Heikonen answers these doubts by stressing that the main idea of AIV method was to use the precise pH level 3-4. By doing the first experiment with chopped hay and hydrochloride acid, Karström was carrying out an experiment planned by Virtanen (Heikonen, 1996: 164; 1990: 96-97).

The reason for Virtanen's scarce international support as a Nobel candidate may have been his image as an inventor of the practical fodder preservation method. The AIV method was widely licensed in Europe and contacts were made even in Egypt, South-America and the United States (Heikonen, 1993: 38-39). In the early 1930's Virtanen was strongly connected with the fodder baring his initials.

The trouble in the reception of the AIV fodder by the chemistry community may have been one reason why Virtanen started to study more deeply the general problem of biological fixation of nitro-

gen in leguminous plants. Virtanen saw a close connection between these two field of studies: the AIV method preserved the nitrogen content of the fodder and the clearing up of the nitrogen fixation mechanism would help to reinforce the nitrogen supply in the fields. In the early 1930's started a race to clear out the nitrogen fixation mechanism, which he saw as fundamental for life on the earth, and by the end of the decade Virtanen's hydroxylamine theory was ready (Virtanen's Nobel lecture, Nobel Lectures, 1942-1962).

Networks in Action

According to Heikonen (1996: 163) one reason for rewarding Virtanen was that "his inventions and works were really appreciated in Sweden". Virtanen's awarding process, indeed, emphasizes the importance of personal connections. Virtanen was well-known by all of his evaluators. He had stayed in von Euler's and in Christian Barthel's laboratories in the early 1920's. The third evaluator in 1945, Ragnar Nilsson, was von Euler's late student and collaborator (Svenskt Biografisk Lexikon: Ragnar Nilsson). Virtanen had good contacts with the University of Agriculture (*Lantbrukshögskolan*) where Barthel and Nilsson had their chairs. He visited the university in December 1944 giving a lecture on his nitrogen fixation studies. In April 1945 Virtanen repeated his visit to Sweden, this time to Stockholm, lecturing again on the same topic (Nobel Protokoll, 1945: Eskola's nomination letter and von Euler's report on May 14).[10]

Already in 1933 von Euler had actively promoted Virtanen's awarding. According to Heikonen (1993: 22, 146-147) he had then "tried to arrange a Nobel prize" to Virtanen and Søren Sørensen together but the plan was not successful because of "intrigues against Sørensen" (Karström, 1985: 414). According to the plan Sørensen would have been awarded for the invention of the notion of pH and Virtanen for applying it in agriculture. The Finns were probably informed about the plan. For this reason they supplemented their original plan – to nominate Virtanen alone – by a letter two weeks later in which they nominated Virtanen and Sørensen together being the only ones to put forward their co-candidacy (Nobel Protokoll, 1933).

In 1945 von Euler was active again and helped the Nobel committee to recognize the theoretical basis of the AIV fodder and see the nitrogen fixation studies as promising despite the doubts voiced by committee member Christian Barthel. Von Euler's own nominations had kept Virtanen on the list of long-term Nobel candidates when the sudden move of Finnish professors to nominate Gustav Komppa in 1942-44 nearly dropped Virtanen from the list.

Virtanen's relationship to von Euler was reinforced by their mutual understanding in politics. In his wartime letters to Virtanen von Euler sympathized with Finland's struggle against the Soviet Union. "I am sorry, I am too old to come to your front as a pilot", regretted the German First World War pilot during the Winter War when Swedish volunteers were recruited to fight for *Finlands sak*, the Finnish cause (von Euler to Virtanen, 6.2.1940).[11] During the Continuation War, after having heard that the Finns had plans to start a university in the conquered Carelian town of Petroskoi, von Euler proposed himself as a lecturer (von

Euler to Virtanen, 13.1.1943).

Von Euler also had wider contacts with Finnish professors. He was one of the privileged sources of Jarl Wasastjärna, a professor of physics at the University of Helsinki, who acted as Finnish ambassador in Stockholm 1940-1944. "As our friend and a well-known German Nazi he might be able to do something for us", Wasastjärna reported to Helsinki in August 1940 during the period of lively diplomacy in the interwar year of 1940-1941 (Wasastjärna to foreign minister, 1.8.1940).

Von Euler realized the needs of his close colleague who was forced to interrupt his studies because of the war and ended his last evaluation report on Virtanen mentioning that at that moment "a Nobel prize given to Virtanen would benefit scientific research to an extremely great extent" since Virtanen was living trough "an intensive working period" trying to verify his nitrogen fixation theory (Nobel Protokoll, 1945: von Euler's report on August 16). In this way von Euler referred to Alfred Nobel's hope that the prizes should not benefit only retired scientists – like Gustav Komppa (Crawford, 1984: 162). The amount of the award, 121 332 Swedish crowns, was a considerable sum of money in post-war Finland and Virtanen immediately spent a part of it in Stockholm shopping for his laboratory staff (Heikonen, 1993: 160).

Von Euler's Finnish contacts went back to the period of Virtanen's teacher Ossian Aschan (1860-1939), professor in chemistry at the University of Helsinki. It was as Aschan's pupil Virtanen had entered von Euler's laboratory in early 1920's. He was not the only young chemist Aschan sent to von Euler's laboratory and about whose progress he received letters from von Euler (von Euler to Aschan, 25.3.1924 and 3.10.1924).

Their cooperation extended to the Nobel prize. Aschan nominated von Euler four times in 1925-1929 until he was rewarded (Crawford *et al.*, 1987). Von Euler thanked for this support in his letter in 1928 mentioning that he had, however, decided to give up the candidature that year. Next year, when he got the prize, he thanked Aschan for his loyal support (von Euler to Aschan, 10.11.1928 and 18.11.1929).

The shared respect in research took shape also in official contacts. Aschan was a foreign member of the Royal Swedish Academy of Sciences and after his death in 1939 Virtanen was elected as his successor. The Finnish Academy of Sciences (*Suomalainen Tiedeakatemia*) elected von Euler as an honorary member in the same year. The Association of Finnish Chemists (*Suomalaisten kemistien seura*) gave a honorary membership to von Euler in 1941, and the respected Gadolin-medal of the association was awarded him in 1954.

Virtanen's Nobel prize in 1945 was only one episode in a long history of cooperation, which extended over two generations.

That personal contacts had a role to play in 1945 Nobel awards is supported by the experience of the 1944 chemistry prize, awarded retroactively in the same meeting of the Royal Swedish Academy of Sciences as Virtanen's prize. According to Crawford *et al.* (1996) it was partly due to wartime circumstances that the 1944 prize, given for nuclear fission, was awarded solely to German Otto Hahn. Hahn's collaborator, Lise Meitner had had to leave Germany because of her Jewish origin, and was left out of the de-

cisive experiments made in Berlin. Living in Sweden, Meitner, however, published the theoretical interpretation of the experiment, but was left aside from the network of Swedish scientists which contributed to her exclusion from the prize.

In Virtanen's Finnish network both the quest for pure chemistry and his opposition to the Finnish post-war foreign policy were present. Virtanen was nominated by a circle of Helsinki University professors. Representatives from other universities were absent. All of Virtanen's nominators were members of Finnish-minded Association of Finnish Chemists (*Suomalaisten kemistien seura*). Some of his nominators, Eskola and Tuorila, were linked to pro-German policy. These features suggest that Virtanen's renomination by Finns, after a three-year period of Komppa's candidature, was a reaction to the difficult post-war political situation.[12]

The role of the University of Helsinki was central both in scientific and socio-political respects. Its chemical institute was the major institute for pure chemistry in Finland. As a principal scientific institution, the university was a symbol of Finnish culture, whose future was threatened by the Soviets. It is tempting to see Virtanen's quest for theoretical research in the context of national science. Emphasizing pure chemistry was evidently in coherence with the symbolic value of the university as a cradle of Finnish civilization, while applied chemistry served merely practical and economical needs.

Gustav Komppa seems to have been totally excluded from the network of Helsinki University chemists. Although Komppa did not lack influence in Finland, as a founding member of several Finnish-speaking scientific societies, differences between applied and pure chemistry may have reduced the influence of the already aged Komppa (1867-1949). The relationship between Aschan and Komppa was said to be "strained at times, however never exceeding the limits of dignity" (Enkvist, 1972: 124-127). Aschan's successor as a professor Niilo Toivonen put his relationship to Komppa quite frankly writing openly to Komppa that their bad relationship might have caused Komppa's name not to be mentioned in Toivonen's textbook (Toivonen to Komppa, 5.2.1938).

Komppa's exclusion might have had its roots in chemistry itself. Komppa's contemporary and colleague at the University of Helsinki, Ossian Aschan seemed to have represented a totally different way to study organic compounds than Komppa. They both had studied terpenes, but while Komppa concentrated solely on synthesis, Aschan's way to clear up the chemical structures of terpenes were purely analytical. This meant that besides his own experimental work Aschan were comparing and discussing with the whole relevant literature, while Komppa concentrated on experimental work. More 'theoretical' approach obviously helped Aschan to change his field of research easily, camphor and terpene chemistry being only a part of his career. Komppa's contributions were entirely synthetic and in a single field of organic chemistry.[13]

Thus Virtanen's quest for theoretical research, together with his way of moving from one field of research to another, might have had its origin in the scientific style of his former teacher Aschan. In his nitrogen fixation studies Virtanen

had used the methods of organic chemistry, which may have contributed to his failure (Heikonen, 1993: 57).

The strained relationship between academic and applied chemistry did not concern only Komppa. In 1945 differences between academic and applied chemistry managed to split the national front, when the professors from the University of Technology, Yrjö Kauko and John Palmén, did not move to nominate Virtanen but staid behind the candidate of their own university. These differences had came to a head after a series of appointments of new professors in chemistry since the late 1930's. Yrjö Kauko's two attempts to move to the more respected chair at the University of Helsinki was met with resistance from academic chemists, particularly Virtanen in 1943.[14] Virtanen himself had succeeded in crossing this border when he was invited to the professorship of biochemistry at the University of Helsinki in 1939, evidently helped by his studies in nitrogen fixation theory.

Conclusion

The award process of the 1945 Nobel prize in chemistry received by the Finnish biochemist A. I. Virtanen was characterized by wartime conditions as well as the way applied and pure theoretical chemistry were appreciated by the Nobel Committee for Chemistry. Additionally, close personal contacts between Virtanen and his Swedish evaluators smoothed the path to prize.

Virtanen's Swedish contacts obviously helped the Nobel committee recognize his merits. Two of Virtanen's evaluators, Hans von Euler and Christian Barthel, were former teachers. Barthel and Ragnar Nilsson came from the University of Agriculture (*Lantbrukshögskolan*) where Virtanen had good contacts as well. The role of von Euler was, however, essential. As a nominator he kept Virtanen's candidacy alive when the Finns turned their back on Virtanen and nominated Gustav Komppa in 1942-1944. As an evaluator, von Euler showed constant respect for Virtanen's research during the long period of his candidacy managing to convince the committee despite the critical attitude of committee member Christian Barthel.

The wartime circumstances had an impact on Virtanen's and von Euler's relations. Von Euler, described as a Nazi, symphatized with Finland's fight against the Soviet Union. Virtanen was in opposition to the Finnish post-war orientation towards pro-Soviet foreign policy.

Virtanen's Finnish network became apparent when he was nominated for the last and successful time in 1945. It can be argued, that the circle of Finnish professors nominating Virtanen, was characterized by Finnish-minded nationalism and pro-German attitudes to a greater extent than in 1942 when the Finns campaigned for Komppa. In this respect Virtanen's candidacy can be considered as a reaction to the political situation created by the peace agreement with the Soviets in 1944.

The tension between applied and pure chemistry is apparent in Virtanen's award process in three respects. The strained relations between the University of Technology and the University of Helsinki split the national front of Finnish nominators into supporters of Virtanen, on the one hand, and Gustav Komppa, on the other. Virtanen's move from applied chemistry to a more theo-

retical field of research improved his possibilities as a Nobel candidate, because the tradition of the committee guided it to look for more general implications in inventions. This despite the fact that the will of Alfred Nobel tended to emphasize experimental findings with practical benefits at the expense of theoretical contributions.

Consequently Virtanen was rewarded, firstly, for his fodder preservation method and, secondly, for his unfinished studies on nitrogen fixation. This is probably one of the rare times when the committee took into consideration expected results, which later did not live up to their promises. In other respects the committee seems to have followed its traditions. The benefit the AIV fodder had conferred on mankind was emphasized and its theoretical value was acknowledged.

Virtanen was a controversial figure in Finnish history and known for his candid political views. His controversial scientific career has received less attention. Virtanen had internalized the adherence of the scientific community to theoretical work and was passionately trying to attain theoretical results, although finally he was more successful in applied research.

Notes

1 In 1967 Ragnar Granit from *Karolinska institutet* in Stockholm was awarded Nobel medicine prize mainly for works he had done at the University of Helsinki in 1930's. Swedish-speaking Granit had, however, left Finland in 1940's and moved to Sweden.

2 Virtanen had only one noncompatriot nominator (Nobel Protokoll, 1933-1945). In 1901-1933 Nobel laureates received on the average 83 per cent of their nominations from countries other than their own. Even in the case of nonwinners the figure is 42 per cent (Crawford, 1992: 46).

3 Crawford *et al.* (1996) have claimed that wartime circumstances contributed to Lise Meitner's exclusion from the 1944 chemistry prize awarded retroactively to Otto Hahn for nuclear fission in the same meeting of the Royal Swedish Academy of Sciences as Virtanen's prize. The Nobel science prizes of 1919, especially the chemistry prize of Fritz Haber, illuminate as well how post-war political tensions influenced decision-making in the Nobel committee (Widmalm, 1995).

4 In early 1930's German Herman Staudinger and Swede P. Klason were among Finnish nominees. In 1935-1937 Virtanen nominated – together with von Euler – W.N. Haworth who was awarded the prize in 1937 (Crawford *et al.*, 1987: 257-283).

5 For some reason, maybe because of the difficult situation in the Winter War, the Finns did not nominate anybody in 1940 (Nobel Protokoll).

6 In 1942 Komppa's nominators were Sulo Kilpi and Niilo Toivonen from the University of Helsinki, Yrjö Kauko, John Palmén and Helmer Roschier from the University of Technology, F.W. Klingstedt from the Swedish-speaking university *Åbo Akademi* in Turku and Emil Tomula from the Government Agrochemical Laboratory (*Valtion maanviljelyskemiallinen laboratorio*) (Nobel Protokoll, 1942-1944).

7 In 1945 Sulo Kilpi and Niilo Toivonen nominated Virtanen together with Pentti Eskola, Eero Tommila and Pauli Tuorila, who all came from the University of Helsinki (Nobel Protokoll, 1945).

8 Virtanen had ruled out ammonia, a competing intermediate product in the fixation reaction, because he had not found aspartase enzyme in root nodules, which meant that aspartic acid could not have been produced from ammonia and fumaric acid (Virtanen's Nobel lecture, Nobel Lectures, 1942-1962: 80-81; Heikonen, 1993: 53-57).

9 In 1937 Komppa retired from the University of Technology. When Valmari died in 1939 the agricultural and forestry faculty

offered the chair to Virtanen who refused being unwilling to move to a faculty of applied sciences (Heikonen, 1993: 79-80).

10 Virtanen's Stockholm lecture was published in *Nature* (Virtanen, 1945).

11 Von Euler took his last "militarily interesting" flight in the Continuation War when he was invited by German troops, located in Northern Finland, to visit the front (von Euler, 1873-1964: 86; von Euler, 1962: 65-69).

12 Having once been established the circle of Helsinki University professors was active again in the following year of 1946 when Virtanen, together with four of his former nominators (Sulo Kilpi, Niilo Toivonen, Eero Tommila and Pauli Tuorila), nominated German Hermann Staudinger – rewarded in 1953 (Nobel Protokoll, 1946). With an only exception of Tuorila, who had his post in the faculty of agriculture and forestry, all these professors had their chairs in pure chemistry, in the mathematical-scientific faculty.

13 Aschan's successor Niilo Toivonen put Komppa's style like this: "His way to do research was, however, opposite to that of Bredt or Aschan, who draw their conclusions from the structures of decomposition products of camphor molecule" (Toivonen, 1949: 94; see also Hückel, 1952 and Hückel, 1941).

14 Kauko was defeated first in 1938 by Sulo Kilpi and later in 1943 by Eero Tommila, who both were Virtanen's nominators in 1945 (Matemaattis-luonnontieteellisen osaston pöytäkirjat, 27.5.1938 and 7.10. 1943).

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