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Physics in Perspective

The Physical Tourist

Physics in Helsinki*

Peter Holmberg**

I trace the origins of teaching and research in physics and astronomy during the 17th and 18th centuries at the Academy of Turku (Åbo), which was relocated to Helsinki in 1827 and renamed as the Imperial Alexander University of Finland, and which in turn in 1917 became the University of Helsinki. I discuss the growth of physics in Helsinki during the 19th century, which culminated in the opening of a large new Physical Institute in 1911, pointing out the individuals responsible for these developments and the sites associated with them. I also discuss related events, such as the founding of a new astronomical observatory and a new magnetic observatory and the development of technical education in Helsinki. I conclude by discussing the construction of an accelerator laboratory and other important developments in physics in Helsinki after 1945.

Key words: Academy of Turku (Åbo); Imperial Alexander University of Finland; University of Helsinki; Physical Cabinet; Magnetic Observatory; Physical Institute; Polytechnical Institute; University of Technology; history of physics; history of chemistry; history of astronomy; radioactivity; physics education; technical education; Van de Graaff accelerator; Georgius Alanus; Friedrich Wilhelm August Argelander; Adolf Edvard Arppe; Pehr Adolf von Bonsdorff; Henrik Gustav Borenius; Count Per Brahe; Nils Fontell; Sigfrid Aronius Forsius; Jacob Gadolin; Gustaf Gabriel Hällström; Viktor Theodor Homén; Adalbert Krueger; Kalervo V. Laurikainen; Selim Lemström; Adolf Moberg; Johan Jakob Nervander; Lars William Öholm; J.A.J. Pippingsköld; Lennart Simons; Karl Fredrik Slotte; August Fredrik Sundell; Paavo E. Tahvonen; Hjalmar Tallqvist; Henrik Johan Walbeck; Jarl A. Wasastjerna; Fredrik Woldstedt.

Physics in Finland during the Turku Period***

During its period as a great power in the 17th and 18th centuries, Sweden-Finland occupied the southeast coast of the Baltic Sea, creating a continuous coastline that began in Finland and stretched over Karelia, Ingria, and Estonia to Livonia, the entire

* A map of Helsinki and information on public transportation can be found at the website <www.hel.fi/english/services/traffic/maps.html>.

** Peter Holmberg is Professor Emeritus of Physics at the University of Helsinki. He has written textbooks on physics and medical physics and articles on the history of physics in Finland.

*** A map of Turku and information on public transportation can be found at the website <http://opaskartta.turku.fi/index_eng.htm>.

domain being under the rule of the Swedish Crown. The main function of a university then was to educate civil servants for positions in the Church and State, so each of these widespread areas founded its own university to fulfill its needs, resulting in a rapid development of the university system in Sweden during the 17th century. The university in Uppsala had been founded already in 1477; it now was followed by the founding of universities in Tartu (Dorpat) in 1632 and in Turku (Åbo) in 1640. When Pomerania came under Swedish rule in 1647, the university in Greifswald became a Swedish seat of learning, and after Skåne became part of Sweden the University of Lund was founded in 1668.

At the beginning of the 17th century, the Cathedral School of Turku was the highest educational institution in Finland, and in 1630 it was transformed into an upper-level secondary school (Gymnasium). The Cathedral School had had three teaching positions, which now was increased to six. There were two positions in theology and one each in oratory, logic, mathematics, and physics. Ten years later, in 1640, the secondary school in Turku was transformed into a university or academy.[1] Following the Parisian model, a university consisted of four Faculties, Theology, Medicine, Law, and Philosophy, and it was not unusual for a diligent professor to advance within the university and be admitted into the most highly respected faculty, that of Theology. There also was a ranking within the Faculty of Theology, so a teacher could advance to its top professorship. The next step was an appointment as Bishop. The first Chancellor of the Academy in Turku was Count Per Brahe (1602–1680), who held this position from 1646 to 1680. The Vice-Chancellor was Bishop Isac Rothovius (1570–1652), who enjoyed great power and influence, since three of his sons-in-law also sat in the Senate of the Academy.

The first professor of physics in the Academy in Turku was Georgius Alanus (1609–1664), M.Sc., who had been Lecturer in Physics and Botany in the secondary school. Physics then comprised the natural sciences and thus included botany, zoology, and anatomy (the word physics stems from the Greek *physis* or nature). Mechanics and optics, however, were not included in physics but were taught by the professor of mathematics. Physics teaching consisted of lecturing and supervising the public defense of students' dissertations or theses, which often were written by the professor himself. The public defense of dissertations was considered very important and instructive for students, which led to the retention of this custom.

The professors of physics in the Academy in Turku contributed to science by making observations of phenomena and carrying out experiments. Thus, Andreas Thuronius (1632–1665) observed the comet of 1664, and Anders Planman (1724–1803) observed the transits of Venus in 1761 and 1769 from which he calculated the parallax of the Sun. Jacob Gadolin (1719–1802), President of the Royal Swedish Academy of Sciences, participated in the preparations for the former observation of the transit of Venus and also made other observations in Turku. Several professors in Turku were elected as members of the Royal Swedish Academy of Sciences. At the same time, some sought higher academic status, and when the opportunity arose transferred to the Faculty of Theology where they made new careers. Johan Browallius (1707–1755), Karl Fredrik Mennander (1712–1786), and Gadolin, for example, became Bishops in Turku, and Mennander rose further to become Archbishop in Uppsala.

Early Astronomy at the Academy in Turku

Early astronomers made observations of stars and their positions, which demanded accurate measurements of angles and a good knowledge of spherical trigonometry. They also made triangulation measurements of the Earth which, like the celestial measurements, had highly practical aspects. Thus, they made accurate determinations of latitude and longitude that were of vital importance for seafarers and also were used by cartographers to determine the shape and size of the Earth.

Jacob Gadolin (1719–1802) was one of the pioneers of triangulation measurements in Finland.[2] In 1748 he was appointed to a special cartographical commission and carried out triangulation measurements from Turku over Ahvenanmaa (Åland) to Grisslehamn in Sweden using a 3-foot quadrant that probably had been used earlier by Pierre de Maupertius (1698–1759) in making measurements in the Torneå valley. When Gadolin became Professor of Physics at the Academy in Turku in 1753, Johan Justander (1713–1774) succeeded him as observer on the cartographical commission and carried out triangulation measurements between Turku and Helsinki. Later, Henrik Johan Walbeck (1793–1822) carried out further triangulation measurements.

Since there was no professorship or even a position in astronomy in Finland at this time, physicists carried out astronomical observations and calculations that were required to establish the dates of Church holidays. A pioneer here was Sigfrid Aronius Forsius (ca. 1550–1624), who was born in Helsinki and rapidly established a reputation as an astronomer, eventually becoming Professor of Astronomy in Uppsala and later Astronomer Royal. His first *Almanac or Counting of Days* (*Almanach eller Dagharäkning*) appeared in 1608 and was calculated *To Stockholm's Horizon* (*Til Stockholms Horizont*). In all, he compiled some thirty almanacs and prognostics. His almanac for 1623 was calculated for use in Turku, as noted on its title page: "To Turku Horizon. To Viborg add 1 hour/34 minutes. To Tallinn and Helsinki [add]/ 50 minutes. To Stockholm subtract 43 minutes. To Elfsborg subtract 52 minutes."* Forsius lived a colorful life, with great successes and upheavals alternating with more peaceful periods. He died while serving as a pastor in Tammisaari.[3]

Besides such more or less routine calculations, astronomical observations also were carried out in Finland, usually occasioned by some extraordinary celestial event. Thus, as noted above, Andreas Thuronius observed the comet of 1644 and Anders Planman observed the transits of Venus in 1761 and 1769. These transits of Venus stimulated a large international project, and observations were carried out in Sweden at several locations. Planman, a skillful mathematician, was given the task of compiling these Swedish observations. He reported a value of 8.2 seconds for the solar parallax. Somewhat later, Gustaf Gabriel Hällström (1775–1844), Professor of Physics in the Academy in Turku, observed solar eclipses in 1802, 1803, and 1804 and the transit of Mercury in 1802. From these observations, he determined the longitude of Turku to be 1 hour 19' 51" east of the Paris Observatory and its latitude to be 60° 27' 11.3" North, as compared to Gadolin's value in 1750 of 60° 27' North.

* *Til Åbo Horizont. Til Wijborg lägg til 1. Tima /34 min. Til Refle och Helsingfors /50 min. Til Stockholm dragh aff 43. min. Til Elffsborg / tagh aff 52. min.*

Fig. 1. The observatory in Turku, which was constructed according to the plans of Carl Ludvig Engel and was situated at Vårdberget. From the astronomer's apartment there was a nice view north over the Aura river and the city. *Credit*: Photograph by N.E. Wickberg, Museum of Finnish Architecture.

Hällström's commitment to astronomy led him to suggest that an astronomical observatory and position should be founded in the Academy in Turku. His efforts were rewarded in 1817, when the Academy decided to establish an observatory (figure 1) and also that the astronomer should serve as its director, be given living quarters in the observatory, and be compensated at an annual salary of 120 silver rubles. An adjunct also was to be appointed at an annual salary of 96 silver rubles, the higher salary going to the astronomer because he also had to carry out the calculations for the annual calendars published by the Academy. Earlier, the Academy had paid 200 silver rubles for this task alone, so it even managed to save some money by appointing an astronomer.

Henrik Johan Walbeck (1793–1822) was appointed as the first astronomer at the new observatory in Turku.[4] He was born in Turku, became a student in the Academy in 1808, and defended his Masters' thesis on September 20, 1815, which was on Johann G.F. von Bohnenberger's and Heinrich W.M. Olbers's equations for calculating longitudes from observations of eclipses and transits of stars.[5] These equations involved constants that depended on the inclination of the plane of the ecliptic, the latitude, and the radius of the Earth, which he calculated for 56 European sites. He received his degree on October 13, 1815; his friend and fellow student, Carl Gustaf Ottelin

Fig. 2. Henrik Johan Walbeck (1793–1822), astronomer at the Academy in Turku from 1817-1822, as depicted in a sketch by G.W. Simberg in 1822. *Credit*: University of Helsinki Museum.

(1791–1864), was given the honor of being *gratist* but could not be the speaker,* so this honor was given to Walbeck, "the utmost mathematical genius, son of the parish clerk and organist." Later that fall, he presented a second thesis in which he calculated the exact time that a solar eclipse would occur one year later for the Turku horizon.[6] On March 2, 1816, he presented a third thesis,[7] in which he applied the method of least squares to George Gilpin's measurements of the specific gravity of water at different temperatures. A few years later, Hällström tackled this same problem so successfully that he received a prize from the Royal Swedish Academy of Sciences for it.

In 1817 Walbeck (figure 2) described a method for determining longitude by observing the distance of the Moon from a star and used it to calculate the longitude of Turku, finding 1 hour 19' 31.84" east of the Paris Observatory. He published perhaps his most

* Ottelin had excelled on the examination for his degree and hence was chosen as *gratist*, that is, he did not have to pay the customary fee to attend the ceremonies to receive his degree. Each time only one *gratist* was chosen who ordinarily had to give a speech, but this honor was given to Walbeck instead.

important work, however, in 1819 when he used the method of least squares to calculate the shape and dimensions of the Earth on the basis of six prior geodesic measurements.[8] The values he obtained were 57,009.76 toisers* for the length of one quadrant of the meridian and 1 part in 302.78 for the flattening of the Earth. This was the first time that these figures had been determined from several different measurements, and his work brought him immediate recognition.[9] He sent a copy of it to F.G. Wilhelm Struve (1793–1864) in Dorpat (now Tartu in Estonia), who was impressed with it and invited Walbeck to Dorpat. Struve was then carrying out triangulation measurements from Jekabpils in Latvia to the island of Hogland in the Gulf of Finland,[10] and he now assigned Walbeck the task of planning a network of further measurements to extend them into southern Finland. This work demanded more time than Walbeck could give it, however, and its eventual completion in 1852 fell to others.[11]

Walbeck's tasks as astronomer at the observatory in Turku included an obligation to obtain new instruments for it, and in July 1820 he undertook a voyage to Germany, visiting various observatories and ordering Utzschneider and Fraunhofer instruments in Munich. Walbeck had acquired his knowledge of astronomy on his own in Finland, and this journey acquainted him with some of the great observatories in Europe. He returned to Finland by way of Königsberg (now Kaliningrad), where he met Friedrich Wilhelm Bessel (1784–1864). He also stayed a short time with Struve in Dorpat, where he became the first to observe a new comet in early 1821. He arrived in Turku in March 1821 with a bright future ahead of him. It was not to be. In the summer of 1822, while traveling in Finland in search of suitable triangulation sites in the region of Padasjoki and Lake Saima, an accident occurred in which he suffered a severe head injury. He lapsed into a deep depression a few weeks after returning to Turku, and on October 23, 1822, committed suicide on the second floor of the observatory by cutting his throat.

Despite this tragedy, the Academy resolved to continue its astronomical work, and its Consistory immediately began searching for a replacement for Walbeck who could use the fine instruments he had purchased. Walbeck had not lived long enough to establish a school of astronomers, so the Academy had to seek his successor from abroad. The Consistory identified as its first choice the Prussian astronomer Friedrich Wilhelm August Argelander (1799–1875), who after some negotiations submitted his application and was elected to the chair of astronomy.[12] On their journey to Turku, Argelander and his wife, Maria Sophia Charlotte Courtan, passed through Dorpat and stayed nine days in Struve's house.[13] They arrived in Turku on August 12, 1823.

Argelander (figure 3) began a series of observations in Turku in February 1824 using Walbeck's instruments and others that he had acquired, including a Liebherr 2-foot repeating circle, an 8-foot transit telescope, and a Reichenbach and Ertel meridian circle. He made a vast number of observations and published his results in a three-volume work in 1831–1832.[14] Earlier, from February 1827 to May 1831, he had made observations of the proper motions of 560 stars, which he published in Helsinki in 1835,[15] a star catalogue that also is known as Argelander's *Catalogue Aboensis*. From his calculations of stellar proper motions he also determined the motion of our own planetary system

* A toiser was equal to 6 French feet or about 1.949 meters.

Fig. 3. Friedrich Wilhelm August Argelander (1799–1875), astronomer in Turku from 1823–1828 and Professor of Astronomy at the Observatory in Helsinki from 1828–1837, as seen in a portrait by Carl Peter Mazer of 1837. *Credit*: University of Helsinki, Galleria Academica.

in the universe, a work for which he received the prestigious Demidoff Prize of the Royal Academy of Sciences in St. Petersburg in 1831.

Argelander made the above observations despite a disastrous interruption in 1827. He was observing the star *beta Aquila* on September 4, 1827, when around 9 P.M. he made the following entry in his notebook, which today is on display in the Helsinki observatory: "Here the observations were interrupted by a horrible fire that laid Åbo [Turku] in ashes."* Within two days, the Great Fire in Turku completely destroyed most of the town, including the main building of the Academy, its library, and its valuable

* *"Hier wurden die Beobachtungen durch eine grässliche Feuerbrunts unterbrochen, die Åbo in Asche legte."*

collections. Like other towns in Finland, Turku consisted mainly of wooden buildings through which the fire spread rapidly, destroying a total of 2,543 buildings in the city center. The only buildings that were spared were some distance away, like those in Klosterbacken. The observatory also was spared, and on September 9, after an interruption of only five days, Argelander resumed his observations.

Six weeks later, an Imperial Manifesto dated October 21, 1827, decreed that the Academy in Turku would be relocated to Helsinki and renamed as the Imperial Alexander University of Finland. Nevertheless, the Academy continued to operate for another year in Turku, the Consistory holding its last meeting there on September 12, 1828. At first, the new university in Helsinki was provided with temporary space in the eastern part of the Senate Building (later the Governor General's house). This arrangement persisted until a new university building was constructed on Helsinki's Big Square (now Senate Square).

Helsinki becomes the Capital and Site of the University

As a young city, Helsinki experienced fires, epidemics, and war. Its annals relate that in 1657 the whole town burned down and that 1695–1697 were years of bad crops and famine that resulted in a high mortality of its citizens. In 1710, the plague took the lives of 1,185 of its inhabitants. Three years later, the Russian fleet attacked, and the troops in the garrison set the town on fire as they retreated; most of the people fled, only to return when peace was established in 1721.

In 1742, Helsinki again was conquered by the Russian army but not totally destroyed. The Swedish Crown then decided to fortify the city. An old map by Augustin Ehrensvärd (1710–1772) shows how Siltavuori (Broberget) was to be fortified to protect Helsinki against attacks from the north, and how Ulricasborg, more to the south, was planned as a garrison for the army.[16] These fortifications, which were begun in 1748, were stopped the following year,* and Sveaborg (Suomenlinna) was fortified instead. The houses in Helsinki were concentrated on its harbor and in the region around today's Senate Square where the Hämeentie road began and extended to Pitkäsilta and the bridge to Musholmen, where it joined the old road from Turku to Porvoo and Loviisa and extended eastward into the Russian Empire. Helsinki at that time was so small that John Carr (1732–1807), who traveled around the Baltic Sea in 1804, did not even visit it but instead visited Porvoo and Meltola (Mjölbolsta), a small site 70 kilometers to the west.[17]

Helsinki began to grow after the Russian-Swedish war of 1808–1809 and the annexation of Finland by Russia as an autonomous Grand Dutchy. On March 27, 1812, Helsinki was established as the capital of Finland. In 1821, the Imperial Senate was moved to Helsinki from Turku and, as noted above, after the Great Fire in Turku in 1827 the university also was moved to Helsinki. Within twenty years the population of Helsinki doubled, from 7,021 in 1820 to 13,175 in 1842, with the inhabited area spreading to Kruunuhaka and Siltavuori.[18]

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* The planned fortifications can be seen on a map of 1749 by Jonas Hahn that depicts the waters around Helsinki.

In 1816, after Helsinki became the capital and administrative center of the autonomous Grand Dutchy of Finland, the Berlin architect Carl Ludvig Engel (1778–1840) was appointed to draw up plans for the central part of the city. Its small area and mostly wooden buildings enabled Engel to transform it and erect new monumental buildings, as shown in a map by Claës Kjerrström of 1878 (figure 4).[19] Today Senate Square is still a large open square that provides expansive views of the surrounding buildings: The Nikolajkyrkan (Cathedral) (1) is on its northern side; the main building of the university (2) is on its western side; the Senate House (3) is on its eastern side; and smaller houses line its southern side. The oldest stone building in Helsinki, the house once owned by the tradesman Johan Sederholm (1722–1805) (4), is still standing on its southeastern corner. Walking north along Unionsgatan, we first see the University Library (5) on the left and then the old Russian Army Hospital (6), which later became the IV clinic for internal medicine of the university and today houses the humanities and social sciences; the facades are original but the interior has been renovated repeatedly. On the right-hand side of Unionsgatan is the General Hospital (7). On the left-hand side, just before the bridge leading to Musholmen, is the Botanical garden (8), and on the right-hand side is Siltavuori (9), which still has no dwellings. At the corner of Nikolajgatan and Regeringsgatan is the Arppeanum (10), a new building built for chemistry in the 1860s, and in Kaisaniemi Park is the Magnetic Observatory (11). On the lot in Fabianinkatu is a building that was constructed for chemistry (12) before it moved into the Arppeanum; today it has been modernized and annexed by the University Library, but the facade is original.

The Imperial Alexander University of Finland

As noted above, physics was among the academic subjects offered to students when the university was founded in Turku in 1640. When it then moved to Helsinki in 1827, physics, with its deep traditions, followed along and thus was taught from the outset at the Imperial Alexander University of Finland.[20]

Engel's plans for a new main building of the university were accepted, and the following text can be read in neat handwriting on the drawing: "Accepted and confirmed by His Imperial Majesty in St. Petersburg on February 29/March 12, 1828. By gracious order [of] Robt. Rehbinder."* The university's entrance was on Senate Square, and the building extended over the entire western side of the square (figure 5). It had three floors, starting with a *soubassement*. On its first floor were an office, archive, tax collecting office, and rooms for squires and attendants.** On its second floor was a large festival hall and rooms allocated to physics and chemistry, including a lecture hall to be shared by them, a laboratory, a hall for physical instruments, and a room to house additional instruments, chemicals, and drugs.[21]

Gustaf Gabriel Hällström (1775–1844), the first Professor of Physics, served from 1801–1844, first in Turku and then in Helsinki where he set up the first Physical Cabi-

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* *"Af Hans Kejserliga Majestät i Nåder gillad och fastställd i St. Petersburg den 29 Februarii/12 Martii 1828. På Nådig Befallning: Robt. Rehbinder."*

** *"cancelliet, archive, uppbörds contoir, drängrum, waktrum och fängelserum."*

Fig. 4. Detail of Claës Kjerrström's map of Helsinki of 1878. The large open Senate Square (Senats torgei) is on its lower boundary, and going clockwise around it, we see the Nikolajkyrkan or Cathedral (1) on its northern side; the Arppeanum (10) to the northeast; the Senate House (3) on its eastern side; Johan Sederholm's stone house (4) to the southeast; smaller houses lining its southern side; the main building of the University (2) on its western side; the University Library (5) to the northwest; and the old chemistry building (12) farther west, which was modernized and annexed by the University Library (5) after chemistry moved into the Arppeanum (10). Going farther north on Unionsgatan, we see the old Russian Army hospital (6) on the left and the General Hospital (7) on the right. Still farther north and to the west, we first see the Magnetic Observatory (11) in Kaisaniemi Park and then the Botanical garden (8). To the northeast is Siltavuori (9). *Credit*: Helsinki City Museum.

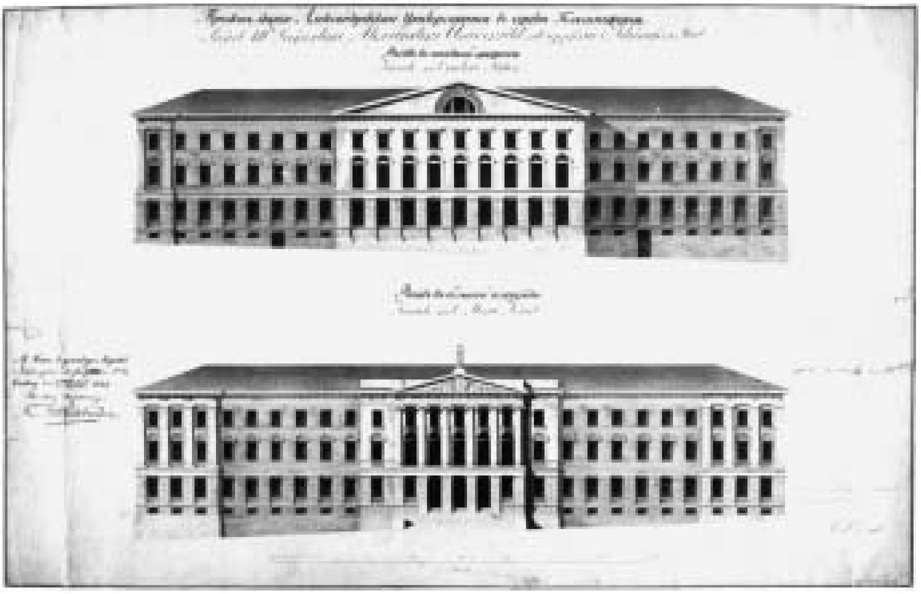

Fig. 5. The facade of the main building of the University on the western side of Senate Square (Senats torgei). On the first floor on the left, space was allocated to physics and chemistry for teaching and keeping instruments, chemicals, and the like. *Credit*: University of Helsinki Museum.

net in the main building of the university.[22] His successor, Johan Jakob Nervander (1805–1848), was Director of the Magnetic Observatory and served as Professor of Physics for only a few years before his premature death. His successor was Adolf Moberg (1813–1895), who served from 1849–1875; he had a profound knowledge of many disciplines and great organizational abilities, which he used to combine various disciplines into larger units and to plan new facilities to accommodate them. He also served as Dean, Vice-Rector, and Rector of the University and concluded his career as State Counselor. His successor, (Karl) Selim Lemström (1838–1904), served from 1878–1904, incorporating the new turn-of-the-century discoveries in physics into his lectures and demonstrations and carrying out research on the Northern Lights that aroused international attention.

The Physical Cabinet

For many years after Hällström (figure 6) set it up, the Physical Cabinet in the Imperial Alexander University of Finland occupied cramped and unsuitable quarters. Physics had only one lecture room, which it shared with chemistry, and a few small auxiliary rooms. Some physicists also worked in the Magnetic Observatory in Kaisaniemi Park (see below), which provided additional space for them, but which was not really suitable for teaching. Eventually, the physical instruments and resources were split between the main university building and the Magnetic Observatory.

Fig. 6. Gustaf Gabriel Hällström (1775–1844), Professor of Physics in both Turku and Helsinki from 1801–1844, as seen in a portrait by Carl Peter Mazer of 1837. Hällström also was ordained and appointed as Vicar of St. Mary's Parish, thus supplementing his meager academic salary. He was the last professor of physics to hold such a double position. *Credit*: University of Helsinki, Galleria Academica.

As physics (natural philosophy) slowly changed its character over the years, new instruments were required for both teaching and research. They were housed in the Physical Cabinet and used in demonstrations during lectures to students and to the general public, who had access to them a few hours each week. A handwritten "List of instruments, etc., acquired by the Imperial University [Academy] in Turku since the beginning of 1811"* cites 590 instruments,[23] most of which were destroyed in the Great Fire of 1827, so a new collection had to be purchased when the university moved to Helsinki. The Rector of the Imperial Alexander University of Finland described the

* *"Förteckning öfver instrumenter, mm., som till Kejserl. Universitetets i Åbo Physiska Cabinett blifvit anskaffade ifrån början af år 1811."*

development of the new Physical Cabinet at three-year intervals. Thus, he noted that for the years 1854–1857, "The Physical Cabinet has obtained 24 new instruments and apparatuses, of which can be mentioned: a large air-pump, a Stöhrer magneto-electric rotational pump, a hydraulic press, a galvanic clock, a Melloni apparatus for radiant heat, and a barometer." The library of the Physical Cabinet obtained 26 physical textbooks in 36 volumes, which was a good start, since only two books had been available earlier.[24] During the next three-year period, additions to the Physical Cabinet included an Amslers planimeter, a stereoscopic viewer, a Gore galvanic rotational apparatus, a Morse telegraph, a static-electricity machine, and several more books. The next three-year period saw the acquisition of 62 more instruments and apparatuses, including a Rühmkorff induction apparatus, a Wrede polarization and interference apparatus, and a spectral-analysis apparatus, as well as 35 new textbooks in 43 volumes. During 1863–1866 more apparatus and 30 new works were acquired.

The collection of instruments, apparatus, and books in the Physical Cabinet thus grew slowly over the years, but the total amount of money provided each year by the Consistory was not large. This was particularly true because the allocation also included the salaries of the teaching assistants. To gauge these allocations, the budget of the university for 1875 shows that a professor's annual salary was 5,500 marks plus a housing allowance of 1,000 marks; the dean was given a supplement of 1,000 marks; a lecturer had an annual salary of 3,000 marks; an attendant 650 marks; and a caretaker 550 marks. By comparison, the Physical Cabinet was allotted 2,000 marks annually, which included the salary of an assistant to look after its instruments.

Chemists and Physicists

The chemists, who occupied the same facilities as the physicists, had similar problems. The University Rules for 1828 state that the professor of chemistry was to be assisted by an adjunct and a laboratory assistant. Pehr Adolf von Bonsdorff (1791–1839) was Professor of Chemistry from 1823–1839 and hence moved with the university from Turku to Helsinki. After his death, Adolf Moberg assumed the professorial duties but the chair remained vacant for several years. Johan Jakob Nervander, who was then Extraordinary Professor of Physics and Director of the Magnetic Observatory, applied for the professorship several times, as did Moberg, but neither presented the required dissertation. In 1846, both Moberg and Adolf Edvard Arppe (1818–1894) applied for the professorship, and both now presented the required dissertation. Nervander, now Professor of Physics, made a recommendation, and it seems that Jöns Jacob Berzelius (1779–1848) in Stockholm did as well. Many members of the Consistory voted for Moberg, but in 1847 Arppe was elected as Professor of Chemistry.[25] Meanwhile, Viktor Hartwall (1800–1857) served as adjunct from 1825–1834 and with von Bonsdorff founded a mineral-water plant in Helsinki, which is still operational. The laboratory assistants were J.F. Elfving, M.Sc., in 1829, the student H. Heikel from 1830–1833, and the former sailor G. Hällsten from 1833–1848, who subsequently moved to Turku and founded a mineral-water plant there. Later adjuncts for shorter periods were A. Laurell, M.Sc., and Adolf Moberg, then a docent in chemistry who later became Professor of Physics and Rector of the University.

During the 1830s, chemistry students prepared some simple reactions, producing zinc oxide, iron sulphate, copper sulphate, and the like for the *approbatur* level for their Masters' degrees. For the *cum laude* level, they investigated more complex preparations like mercury and antimony compounds, and for the *laudatur* level they made, for example, qualitative and quantitative analyses of minerals. Pharmacy and medical students also had to pass preparatory examinations in chemistry and to carry out laboratory work. The number of chemistry students thus increased rapidly and required an increasing amount of space. Eventually, in 1847, after much discussion and planning, new facilities were provided in a new chemistry and anatomy building in Fabianinkatu, thus opening up additional space for the physicists in the main university building.

A decade later, another new chemistry building was in the works. A suitable lot for it was available at the intersection of Nikolajgatan and Regeringsgatan, and the architect Carl Albert Edelfelt (1818–1869) drew up plans that were discussed by the Consistory in 1862. It was to be a four-story, stone building consisting of a laboratory, an apartment for the professor of chemistry, facilities for mineralogical, geological, and paleontological collections, an ethnographical museum, and rooms for attendants and handymen. The provision of a large apartment of some 400 square meters of floor space for the professor was criticized heavily, but eventually the advantages of having the professor close at hand to supervise the laboratory tipped the scales, and it was included in the plans. The building was constructed between 1866–1869, and since Arppe was then Professor of Chemistry and Rector of the University, it was called the Arppeanum (figure 7).

The chemists now had a large building available to them, and after a while space was allocated in it to house the Physical Cabinet. Then, however, new problems arose. The large laboratory occupied several floors, was in close proximity to other facilities, and had a malfunctioning ventilation system. Thus, in his report of 1878 the Rector noted that "it has not been possible to combine the laboratory and the facilities for other purposes in this beautiful and expensive building." The following year, plans for another new building were drawn up by the architect K.G. Nyström (1856–1917). In 1884 they were accepted and between 1885–1887 the building was constructed on Regeringsgatan, forming a wing of the Arppeanum. Today this wing has been converted into an office building, while the Arppeanum is being restored to accommodate the University Senate on its first floor and the University Museum on its other floors. During these changes, the chemists had to move into several small facilities in Kruunuhaka, but today they occupy a large new building in Kumpula, the new site of the University campus.

The New Astronomical Observatory in Helsinki

When the university moved to Helsinki in 1827, it issued new regulations that transformed Argelander's position as an astronomer into a professorship, to which he was elected without having had to present the customary required dissertation. This was unique in Finland and generated some opposition from members of the Consistory.[26] In any case, Argelander remained in Turku until 1831, continuing his observations there. He then spent a year on leave with relatives in Prussia, and finally moved to

Fig. 7. The Arppeanum on Nikolajgatan (today Snellmaninkatu), which was constructed between 1866–1869 to provide more space for chemistry and the geological collections of the Imperial Alexander University of Finland. *Credit*: Photograph by Charles Riis & Co, 1887; Helsinki City Museum.

Helsinki in 1832 where he published his three-volume star catalogue (see above). This required much effort, because the material intended for the first volume was destroyed in J.C. Frenckell's publishing house during the Great Fire in Turku of 1827. In Helsinki, Argelander also supervised the building of a new observatory that had been designed by Carl Ludvig Engel on the Ulricaborgsberget (figure 8), a high hill in the southern part of Helsinki. In November 1834, Argelander then resumed his observations and continued them until February 1837. By then a third German observatory was under construction in Bonn (the two others being in Berlin and Königsberg), and the Prussian Crown Prince, Argelander's good friend since childhood, wrote a personal letter to Argelander imploring him to return to Germany as head of the Bonn observatory. Argelander submitted a letter of resignation to the University Council, which received it on January 14, 1837, and sorrowfully accepted it. Argelander moved to Bonn and gained further renown there through the publication of his three-volume *Uranometrica nova* (Berlin, 1843) and other influential star catalogues.

To locate a successor to Argelander in Helsinki was difficult, since he had not been there long enough to establish a school of astronomers. For a time, Fredrik Woldstedt (1813–1861) looked after the instruments at the Observatory; Johan Jakob Nervander lived in its apartment carrying out terrestrial-magnetic measurements while waiting for the new Magnetic Observatory to be constructed; and Henrik Gustav Borenius (1802–1894) assumed the teaching duties and then, in 1841, declared his candidacy for

Fig. 8. The Astronomical Observatory, which was designed by Carl Ludvig Engel and completed by 1834 on the Ulricaborgsberget, a high hill in the southern part of Helsinki. Today it is surrounded by large trees. *Credit*: Helsinki City Museum.

the vacancy. Meanwhile, however, Gustaf Lundahl (1814–1844) had gone to Bonn to study under Argelander and then had continued his studies under Wilhelm Struve in Pulkovo, Russia (where Struve had moved in 1834). Lundahl presented his dissertation and, with outstanding recommendations from Argelander and Struve, was elected to the professorship of astronomy in Helsinki in 1842. Two years later, he died at the age of 30.

Woldstedt was elected as Lundahl's successor, but he too became ill at an early age, and part of his teaching duties was taken over by Lorenz Leonard Lindelöf (1827–1908). When Woldstedt died in 1861, his student Hugo Gyldén (1841–1896) was only 21 and was considered too young for the chair, although he later had a brilliant career in Russia and Sweden. The university thus again had to look abroad for a candidate, and Adalbert Krueger (1832–1896) was elected as Professor of Astronomy in 1862.[27] Krueger had been Argelander's student in Bonn, had helped Argelander carry out his observations for his star catalogue, and had married Argelander's daughter Maria Wilhelmina Amalia. He remained in Helsinki for fourteen years, during which time he published 55 works. He then became Director of the Gotha Observatory and later Director of the Kiel Observatory.

The Magnetic Observatory in Helsinki

Johan Jakob Nervander (1805–1848), future scientist and poet, was the son of Johan Nervander, a pharmacist in Nystad, and Beata Bergbom. The family had been well off, but the father's speculations in shipping and an import business brought the family to economic ruin. The youth was able to acquire an education, however, and entered the Academy in Turku in 1820 where he was a brilliant student. He first concentrated on the humanities, intending to become a poet, but then switched to science and physics,

Fig. 9. Johan Jakob Nervander (1805–1848), Director of the Magnetic Observatory from 1839–1848 and Professor of Physics from 1846–1848, as seen in a portrait by E.J. Lind of 1832. *Credit*: University of Helsinki Museum.

completing his studies with distinction in 1827: Of a maximum possible of 33 points on the final examination for his degree, he received 30 points in 11 different subjects – a record that remained unbeaten as long as the examination covered that many subjects.

From 1832–1836, as the first recipient of a major traveling scholarship, Nervander (figure 9) journeyed throughout central and southern Europe, meeting many famous physicists. He also invented the *tangentbussol*, a sensitive galvanometer for measuring weak electrical currents, which brought him international acclaim.[28] After returning to Finland, he anticipated making an academic career in Helsinki, but old professor Hällström showed no signs of retiring. Nervander's impatient letters to the University Council, suggesting how to remove Hällström, were not well received and earned him the reputation of a troublemaker. Hällström's scientific competence and organizational abilities prevented his removal.[29]

Fig. 10. The Magnetic Pavilion in Kaisaniemi Park as seen at the beginning of the 1900s. *Credit*: Finnish Meteorological Institute.

Nervander found more understanding among scientists in St. Petersburg; he visited there often and many of his results were published by the Imperial Academy. He also acquired influential advocates there, for example, the Academician Adolf Theodor Kupfer (1799–1863),[30] who supported his proposal to establish a magnetic observatory in Helsinki. In April 1838, an Imperial decree to establish a Magnetic Observatory in Helsinki was read at a meeting of the University Council. Its planning and construction in Kaisaniemi Park proceeded quickly; it was completed and ready for use in November 1839.[31] Nervander was appointed as its Director and as Extraordinary Professor of Physics. He finally realized his goal of succeeding Hällström as Professor of Physics in 1846, but only two years later he fell ill with smallpox and died.

Nervander's interest in the Earth's magnetism had grown during his Grand Tour in Europe, and he had worked hard to establish a magnetic observatory in Helsinki along the lines of those already in existence in Russia, thus extending the area covered by magnetic observations to include the western part of the Russian Empire. He set as his goal as Director of the Magnetic Observatory to secure its future by connecting his observations to international projects. His plan was accepted in St. Petersburg in 1841, and he decided to schedule his observations during the same period of time as those being made by the British South Pole expedition.

The Magnetic Observatory in Helsinki (figure 10) was a huge undertaking by Finnish standards. To understand its scale properly, it has to be compared to other scientific projects at the university in Helsinki. Hällström, the Professor of Physics, had only a few rooms at his disposal in the southern part of the main university building, which he shared with the chemists, and his personnel included only a lecturer, a docent, and occasionally an assistant. Nervander, as Extraordinary Professor of Physics and Director of the Magnetic Observatory in Kaisaniemi Park, had a large building at his disposal that included living quarters for himself and his family. One room also was reserved as a commons room for his assistants – no less than twelve of them – who made observations day and night at ten-minute intervals at the outset of Nervander's international project, which required very substantial resources and utilized superior apparatus. It was Big Science at the time.

After Nervander's sudden death in 1848, Henrik Gustaf Borenius (1802–1894) was appointed as Director of the Magnetic Observatory. Borenius had married one of Nervander's daughters and had had close relations with his father-in-law. He now followed Nervander's routines and schedules for many years. Finally, after he retired in 1880, the meteorological system was reorganized in Finland, and the Magnetic Observatory, which until then had come under the rules of the University, now was turned to making meteorological observations and was taken over by the Finnish Society of Sciences and Letters.[32] Its routines and schedules also changed. As noted above, Nervander had taken instrument readings every ten minutes, entering them into journals. He had adhered to this demanding schedule from 1844 until his death in 1848, and Borenius continued this system until 1856. Then, until his retirement in 1880, he took readings once per hour, a schedule that was followed until 1897. Finally, from 1898–1911, readings were taken three times per day, which diminished to once per day during 1911. At that point, they were stopped altogether owing to disturbances that were created by the electric-tram traffic passing close to the observatory.

Nevander had measured the magnetic declination and the intensity of the horizontal component of the Earth's magnetic field, and at first he also had noted the intensity of the vertical component. His collection of data from the period 1844–1848 was published posthumously in four volumes in 1850 and was awarded a prize by the Imperial Academy in St. Petersburg.[33] He had taken his first measurements on July 1, 1844, precisely at 0 hour, 0 minute, and subsequently took readings every ten minutes until February 29, 1848, precisely at 2300 hours, 50 minutes. After his death, as noted above, the observations were continued, but they were not published. Fortunately, however, all of the original notebooks were preserved and are held today in the Institute of Meteorology in Helsinki. Recently, Heikki Nevanlinna and his colleagues have analyzed all of this data with the aid of computers and have published the results.[34] Thus, the work begun by Nervander 150 years ago and continued by his successors has come to a close. The magnetic-declination readings, some 1,010,000 of them, cover a period of five sunspot cycles, almost two cycles longer than the longest series of data so far recorded with the activity index (aa).*

* The activity index (aa) is a geomagnetic activity index that characterizes the level of geomagnetic disturbance in three-hour time sequences. Ultimately, the changes in the aa-index depend on the solar activity that causes the geomagnetic storms. Long-term series of aa-indexes give useful indirect information on slow solar activity and solar-radiation output. See M. Menvielle and A. Berthelier, "The K-derived planetary indices: Description and availability," *Geophysical Review* **29** (1991), 413–432.

The Physical Cabinet (Continued)

When chemistry was assigned a building of its own in 1847, the Physical Cabinet still remained in the main university building, but the large laboratory in it was taken over by the university administration. Later, in 1879, this laboratory space was returned to its original purpose as a place to house the "physical-mathematical instrument collections." The space available was not large, however, and it had to be shared with other disciplines. Nevertheless, it could be used for physics teaching without too many problems: There were not a large number of advanced students, since many of the beginning students, for whom the basic courses were obligatory, did not go on in physics but completed their degrees in other fields.

The Arppeanum had been designed by the architect Carl Albert Edelfelt (father of the renowned artist Albert Edelfelt [1854–1905]) and was built between 1866–1869 at a cost of 469,946 marks, of which 54,765 marks were spent mostly on equipment for the chemistry laboratory. An additional 50,000 marks were required to pay for and prepare the building site in 1866.[35] The Physical Cabinet now was housed on the top floor of this building in a large hall with windows facing south. It served as an office, library, instrument hall, and room for carrying out special experiments. Adjacent to this hall was a smaller one that served as a storage room for instruments and a place for beginning students to work. Another room was used by the teachers for research purposes. In addition to these three large rooms, the physicists also had a small room in the attic for special projects and a room on the ground floor that served as a workshop.

When Selim Lemström (1838–1904) became Professor of Physics in 1878, he immediately set out to improve the working conditions of the physicists, and two years later his plans were implemented. They involved some relatively extensive renovations. Workbenches were mounted against the walls of the large halls, and one of them was completely furnished with 6 cupboards, 4 tables, and 8 chairs, as well as 6 tripods, three of which had mechanisms for raising and lowering them. Gas and water also were installed. Moreover, since the physics lectures were held in the chemistry auditorium on the ground floor, sometimes heavy and bulky instruments had to be transported between it and the Physical Cabinet on the top floor, so a hoist was installed for this purpose.

Lemström (figure 11) was a devoted experimentalist whose efforts centered on constructing new instruments, taking measurements, and compiling their results.[36] Earlier, when he had traveled abroad on a scholarship visiting various European laboratories, he constantly had compared them with conditions in Helsinki, often finding the latter inadequate owing to the small amount of money that was available for buying new equipment for the Physical Cabinet and carrying out new experiments with it. In 1871, in preparation for a journey to Lapland, he made a long list of equipment to purchase and then bought a magnetometer that was made by the instrument master Sörensen in Stockholm, some copper wire for an electrical-discharge apparatus, an ice-making apparatus, and some tools and a frame for his electric kite,* but even these small purchases strained his meager budget.

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* Lemström was going to use this electric kite to investigate atmospheric electricity and electrical discharges.

Fig. 11. (Karl) Selim Lemström (1838–1904), Professor of Physics from 1878–1904. *Credit*: Finska Vetenskaps-Societeten.

Lemström believed that every good physicist should master experimental techniques, and when he succeeded Adolf Moberg as professor of physics in 1878, he immediately opened a new physical laboratory and proposed that practical work be made part of the examination requirements for a degree in physics, a requirement that was instituted two years later. This requirement demanded at times that experimental work had to be carried out in collaboration with other institutions having the necessary instruments. This was not always frictionless as seen, for example, in a letter that he wrote to N.K. Nordenskiöld (1837–1889), Director of the Magnetic Observatory, on December 3, 1880:

> Through Borenius I heard that you do not wish to allow two students to enter the stone [Magnetic] Observatory. Their situation is that they need to make certain

> determinations regarding the violet spectrum [of the Sun] and these cannot be done at the [Physical] Cabinet until there are shutters on the windows, as the light is too strong and prohibits the observer from seeing the said lines. On the other hand, at the [Magnetic] Observatory there is a window facing south fitted especially for this purpose. These determinations need not take more than a few hours one day when the Sun is shining. By next term it will be possible to carry out such determinations at the [Physical] Cabinet.[37]

Nordenskiöld responded immediately,[38] justifying his refusal but agreeing to allow the two students to use the instruments and facilities if absolutely necessary. His unwillingness arose because just then he was engaged in making an extensive inventory in preparation for the transferral of the administration of the Magnetic Observatory from the University to the Finnish Society of Sciences and Letters.

The laboratory requirement that Lemström had initiated revealed that the instrument collection of the Physical Cabinet, even though it had increased over the years, was absolutely too small and substantially more funds were required for it. On October 1, 1881, its annual allocation was increased from 2,000 to 3,000 marks, and His Imperial Majesty, Czar Alexander III (1845–1894), decreed that "to the University budget, a yearly allocation of 1,200 [marks] will be given for an Assistant at the institution."[39] An additional allocation of 15,000 marks over the three-year period 1881–1884 allowed a further substantial increase in the instrument collection and the purchase of more apparatus for teaching and research, including a theodolite for observing the Northern Lights, a consignment of insulated copper and silver wire, and a mercury vacuum pump after a new design by Lemström's colleague, Extraordinary Professor of Physics August Fredrik Sundell (1843–1924).

The Physics Department Building at Broberget

Despite these improvements, the facilities for the physicists still were inadequate, especially because the number of students had increased greatly owing to the laboratory requirement that Lemström had initiated. During the spring term of 1881, for example, around 70 students had to work more or less regularly in the laboratory to complete their required practical exercises. A committee therefore was appointed in the 1890s to investigate the possibility of building an entirely new physical laboratory and to estimate its costs. The first site the committee considered was on Nikolaigatan (now Snellmanninkatu) between the National Archives and the Pathological Institute. Certain building restrictions, however, revealed that this site was too small.

Meanwhile, the physicists had acquired additional temporary space in a building at Hallituskatu 3 and means to equip it, thus establishing an annex to the physical laboratory. Extraordinary Professor Sundell, who taught mainly medical students, worked there beginning in the fall semester of 1883.[40] A small number of physics students also did their practical laboratory work there. To cover the annual rent, the university applied for 1,300 marks from public funds, as well as for 1,200 marks per year to hire an extra assistant. This temporary solution turned into a more prolonged one. In 1902, the entire physical laboratory moved into the building at Hallituskatu 3, so everything now was under one roof, but the physics lectures still had to be held in the chemistry auditorium in the Arppeanum, the only lecture hall large enough to accommodate them.

The tide began to turn when Professor Emeritus and State Counselor J.A.J. Pippingsköld (1825–1892) left a bequest to the university in his will to establish a Chair of Applied Physics, "so that instruction in the application of physics would include even the most everyday occurrences taken from the area of practical life." The immediate consequence was that the plans for a new laboratory building again were set aside until the new professor could be appointed. Then, on June 26, 1895, His Imperial Majesty, Czar Nicholas II (1868–1918), decreed that a Chair in Applied Physics be established. Three years later, on July 12, 1898, Viktor Theodor Homén (1858–1923) was appointed to it. This then revived the plan of building a new physical laboratory, since now each of the two professors of physics might have his own department in it.

Earlier, in 1897, the committee again had considered and again had rejected the idea of constructing a new physical laboratory on Nikolaigatan. In 1900, it then presented a new proposal to erect the building at a nearby site. Its architect was K.G. Nyström, and its estimated cost was 570,000 marks. It was to be a large, three-story building with a stately facade, and it should include a semicircular *Auditorium maximum* and several laboratories and other facilities for students and professors. Homén commented:

> Here we live in our easy space; I on my part am working on the establishment of my collection of physical instruments. We have accomplished the drawing of a new and splendid physical laboratory, but we are having some problems with the site. If we do not get the place we prefer, then there is still another which the University purchased for the physical laboratory before my time, though it is not as good as the aforementioned one.[41]

The University Council approved the new physical laboratory, but His Imperial Majesty turned it down.

Physics teaching and research, nevertheless, had to continue. Between 1899–1902 the practical laboratory work of students was divided between three different locations.[42] About ten students per term were doing special projects for the *laudatur* degree, while about 60 per term were studying for their Masters' degrees, about 25 per term were doing work to prepare themselves for the entrance examination into medical school, and others were doing laboratory work as part of their education to become gym teachers. Instruction also took place under Homén in the laboratory of applied physics, which had its own budget and was located in the rented annex at Hallituskatu 3.

Physics was not the only discipline under stress from the increasing number of students, and the University Council worked indefatigably to improve their working conditions. It saw that the university would have to enlarge its premises considerably in the near future, and it therefore started to explore possible new locations. Attention turned to Broberget (Siltavuori) where many undeveloped lots were soon to be sold by the city. The total area available was 9,274 square meters, enough for four institutes in addition to a lot that already was allocated to the Physiological Institute. In 1905 the University signed an agreement with the city that allowed it to build on this land.

Fig. 12. The new Physical Institute of the Imperial Alexander University of Finland at Siltavuori, which was designed by K.G. Nyström and completed in 1911. Note the tower, which was the first structure that was removed as the building was renovated in later years. *Credit*: University of Helsinki Museum.

Meanwhile, at the end of 1902, another proposal for a new Physical Institute had been submitted, with K.G. Nyström as its architect. Its implementation, however, was delayed by the death of Selim Lemström in 1904 and was taken up again only when Hjalmar Tallqvist (1870–1958) was appointed as his successor as Professor of Physics. Tallqvist and Homén now were empowered to finalize the plans for the new Physical Institute, which they envisioned as being constructed at Broberg Terrace (Siltavuorenpenger). The Imperial Senate approved their proposal in 1908, and at last the final drawings were made. The new, stately Physical Institute (figure 12) was completed in 1911.[43]

It attracted some criticism, however. Lars William Öholm (1872–1944), who later became Professor of Physical Chemistry,[44] told Svante Arrhenius (1859–1927) that:

> Our physical laboratory is now completed. A great part of the autumn semester was wasted as the building work continued until December. They have now been building for two and a half years, and the result is a big, ugly, and expensive building. As a laboratory, it is quite old-fashioned and in many ways a failure, but in part it is good. There obviously have been too many cooks and the broth shows it. None of

> them have been particularly practical or have had enough authority to force through some good ideas. … Lucas [Homén] did have several [ideas] but did not succeed in making his voice heard. He is, however, very glad that he finally, after all, has got his own lab – namely, 1/3 of the building forms his department. Once again he can return to his interest in physics.[45]

Others responded positively. Sundell, for example, wrote to Arrhenius that, "Our new, stately Physics Institute is about to be completed. I shall install myself in one of the rooms there."[46]

To plan a Physical Institute this large required a great deal of foresight, feeling the pulse of the times to sense which areas of physics to develop. Reading the literature, writing to colleagues, discussing ideas with them at conferences, and visiting their laboratories all were means to this end. In general, this was a period of rapid expansion owing to great increases in the number of students and the opening up of new fields of research. Thus, between 1890 and 1900, twenty-four new physical laboratories were constructed in Europe, and between 1901 and 1911, twenty-nine more new ones were added, figures that do not include older ones that were renovated or enlarged. Many of these new physical institutes were similar in their architectural styles and in their technical installations.

Whether ugly or not, badly planned or not, the new Physical Institute in Helsinki has served generations of physicists and their students for nearly a century. It was a large building by international standards and an enormous one by Finnish standards. Nevertheless, not long after it opened, it again was crowded with students and over the years had to be renovated several times. It was the last physical institute in Europe to be constructed with a tower, which was intended for pendulum experiments and meteorological observations, but these needs soon diminished, and the tower was taken down. Next, a new floor was added, and finally the attic was invaded. In addition, the interior walls were moved repeatedly to meet new research requirements. Its main lecture hall, including its pillars, has remained, but its smaller lecture room on the third floor (with an amphitheater ceiling) was converted in the early 1960s into laboratory space. More recently, neighboring buildings have been annexed. Today the Physical Institute in Siltavuori looks quite different from the way it did when it opened in 1911.

Early Experiments on Radioactivity at the University in Helsinki

At the beginning of the 20th century, there were three professors of physics in Helsinki, each of whom was involved in his own research projects and had no time, and perhaps no inclination, to take up new ones. Hjalmar Tallqvist (1870–1958), Professor of Physics since 1904, was interested mainly in classical physics and writing textbooks; August Fredrik Sundell (1843–1924), Extraordinary Professor of Physics since 1880, was devoted to mechanics; and Viktor Theodor Homén (1858–1923), Professor of Applied Physics since 1898, was concerned with meteorological phenomena such as the temperature balance between ground and air and the occurrence of night frosts. All three had been involved in the time-consuming planning of the new Physical Institute, and all three also had positions in private enterprises.

These circumstances explain, at least partly, why no research projects on radioactivity were undertaken in Finland during the early decades of the 20th century. Students carried out a few basic experiments on radioactivity but without strong support from their professors. By examining some of their *laudatur* works and *pro gradu* theses,* we can get a sense of the growing interest in radioactivity and nuclear physics up to the outbreak of World War II.**

The earliest work I have found is a handwritten essay by Kaarlo Aaltio, probably dating to 1906,[48] in which he gives a detailed account of the discovery of radioactivity and describes a method of determining the activity of radioactive substances. For his *laudatur* work, he presented a series of experiments in which he measured the radioactivity of soils and minerals he had collected from different sites around Helsinki.

Five years later, in 1911, Yrjö Tuomikoski, who had spent some time in Ernest Rutherford's laboratory in Manchester, England, used radium as a source of gamma rays and measured their absorption in lead. Next, in 1913, Lars William Öholm visited J.J. Thomson's Cavendish Laboratory in Cambridge and Rutherford's laboratory in Manchester, from where he wrote that he was "attending the course in measuring radioactivity" and was

> working here day in and day out in order to complete all the practical works on radioactivity by the beginning of June, if possible. They will amount to about 50 [practical works]. I have already completed about thirty. They are all quite interesting, and to me they are completely new. I do not intend to remain here longer than necessary and I am not taking on any scientific studies now. My intention was only to learn the measuring methods and there are good possibilities for this.[49]

He also purchased some apparatus:

> I have bought a series of radioactivity apparatus for the Physicum in Helsinki. I approached [Professor] Tallqvist, and he was willing to lay out the 500 [Finnish marks***] so I could purchase a great deal, *i.e.*, 3 good electroscopes, one for alpha [rays], one for beta+gamma [rays], and one for [radium] emanation. I also have [one for] actinium for 32 [marks]. If we get a few more milligrams of radium, we will be well-supplied. But how to get a standard without stealing one certainly will be difficult.[50]

A few years later, Gunnar Nordström (1881–1923) published measurements of the radioactivity of water from twenty-seven wells in Finland,[51] probably using the equipment that Öholm had purchased in Manchester. Other texts, preserved today in the departmental library, are typical review articles. Thus, Georg Sundman reviewed "Recent achievements in the field of radiation,"[52] and Bertil Sjöström's *pro gradu* thesis of 1927 described how to record alpha, beta, and gamma radiations.[53] Later, James Chadwick's discovery of the neutron in 1932 was the subject of several *pro gradu* the-

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* A *pro gradu* thesis is the thesis that is prepared for the receipt of the Master's degree.
** World War II is known as the Continuation War in Finland.
*** A Finnish mark was the currency that was used concurrently with the ruble.

ses that described the nuclear reactions that produced them and other experiments carried out at foreign research centers.

Thus, Finnish physicists were aware of the rapidly developing field of nuclear physics and carried out some basic measurements, but did not make any major contributions to it. As in the case of X rays, physicians recognized the therapeutic possibilities of the radioactive radiations, but to master the requisite experimental techniques, especially how to construct the apparatus to produce them, they had to depend on help from physicists. This soon stimulated fruitful cooperation between physicians and physicists, and together they developed new equipment in the late 1940s to measure the radiations from radioactive substances of use in medicine.

After World War II, everyone became aware of the field of nuclear physics, and the Finnish press often printed reports of recent discoveries and innovations in it as well as human-interest stories. For example, in the fall of 1947 a story appeared telling how nuclear detectors were used to find a missing radioactive preparation. After treatment, a schoolboy had walked out of the General Hospital on Unioninkatu in Helsinki and by mistake had carried with him a radium source. He dropped it somewhere, and although a search for it was started immediately, the little metal plate could not be found. Help came from the physics department when B. Grotenfelt, M.Sc., was contacted by Paavo E. Tahvonen, health physicist at the hospital. Grotenfelt and Lennart Simons had built a portable Geiger-Müller counter, which they now put on a wagon and followed the path the schoolboy had taken. The counter responded in Kaisaniemi Park, and the small piece of metal with the radioactive material on it was found in the wet snow.

The First Accelerator in Finland

The earliest experiments in nuclear physics in Finland were carried out with radioactive sources obtained from abroad. To achieve far greater experimental flexibility required an accelerator, with the choice being either a Cockcroft-Walton accelerator, a Van de Graaff accelerator, or a cyclotron. In the late 1930s, Lennart Simons (1905–1986) had visited Niels Bohr's institute in Copenhagen and had gained experience with the institute's cyclotron, but for economical reasons the Helsinki physicists now decided to build not a cyclotron but a 3-MeV (million-electron-volt) Van de Graaff accelerator.[54] They excavated a cavern in the rock under the main building of the physics department to house it and knew that it would have to be to a high degree "home made." The first dissertations and publications that appeared later dealt with its construction, supporting equipment (detectors and the like), and the development of techniques to determine nuclear parameters.[55]

Work began on the Van de Graaff accelerator in 1947, and it was ready for use in 1956. It took this long to build and bring it into operation because from the outset the goal was to build a high-quality accelerator, and many of its components were unavailable after the war and required a great deal of work to make them fit together properly. In fact, it was something of a miracle that the accelerator was built at all. The success of this project can be understood only on the basis of the enormous enthusiasm it inspired among broad circles of Finnish society. Also essential were excellent contacts

Fig. 13. A garden view of Siltavuori. On the left is the residence of the Prefect or Head of the Department of Physics, which also was completed in 1911. Its last occupant was Nils Fontell (1901–1980), Professor of Physics from 1942–1968, after which it was converted into a physics laboratory. On the right is the Van de Graaff accelerator laboratory, which was inaugurated in 1959, with the central heating plant attached to it. *Credit*: Department of Physical Sciences Collections.

to industry both in Finland and abroad. The latter enabled scientists at the High Voltage Engineering Corporation in America to deliver two accelerator tubes by special permission in 1953 through the ASLA Foundation.* When asked, many companies in Finland also delivered special parts for the accelerator.

As soon as the Van de Graaff accelerator was up and running, it became apparent that the laboratory space under the physics department was far too small for it. Furthermore, the ionizing radiations it produced penetrated walls and ceilings and entered neighboring rooms to a much greater extent than had been calculated. This was a particularly serious problem, since the radiation level in the office of Professor Nils Fontell (1901–1980), the departmental chairman, which was directly above the accelerator, was too high. He had a warning lamp on his desk, and when the accelerator was running and the light was on, he had to leave his office. The only solution was to move the accelerator to another location. In 1957, Parliament reserved a budget to build a new accelerator hall in an annex to the main departmental building, and in 1959 the move was completed (figure 13). The upper floor of the annex is dominated by the accelerator hall, 12 meters high, with the Van de Graaff accelerator and nitrogen gas tanks in it. On the middle floor is the analyzing magnet, detectors, and operating controls. On the lower floor, which is completely encased in the Siltavuori rock, is more laboratory space, electronics' workshops, and the like.

* ASLA stands for Amerikan Suomen Lainan Apuraha, or Grants from the American Loan to Finland.

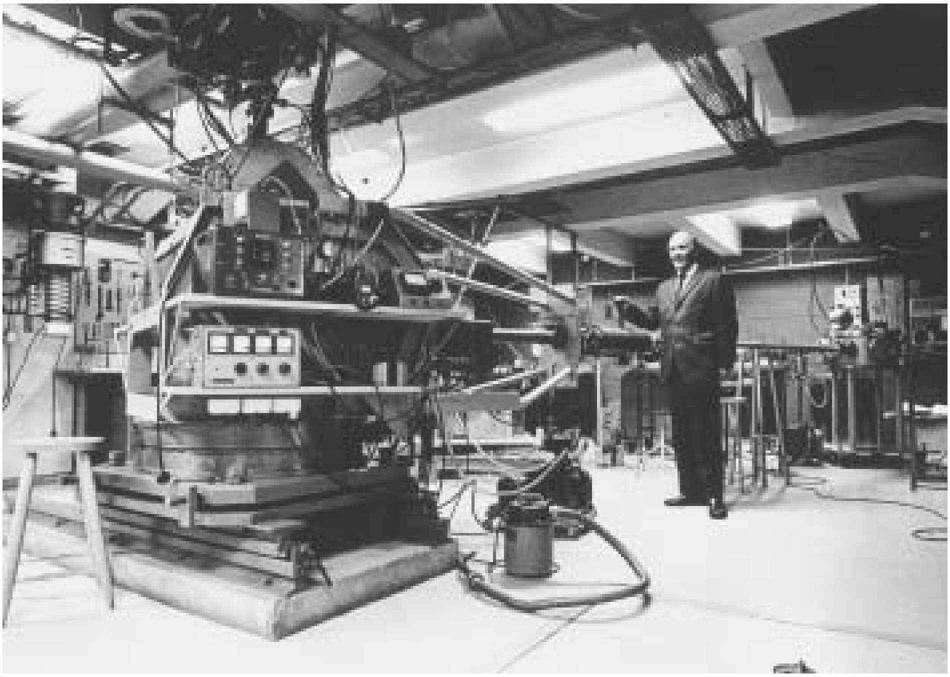

Fig. 14. A man and his lifework. Professor Lennart Simons (1905–1986) standing in front of the analyzing magnet in the Van de Graaff accelerator laboratory at Siltavuori. *Credit*: Peter Holmberg's Collections.

Several teams pursuing different research projects now formed around the Van de Graaff accelerator, opening up new research fields for Finnish nuclear physicists and their students, with the number of their dissertations increasing constantly. More equipment also was installed, first an isotope separator and later a neutron generator for 14-MeV neutrons. In 1968 the physics department was divided into two laboratories, the Institute for General Physics and the Accelerator Laboratory. Professor Lennart Simons (figure 14) was head of the latter. Today a new tandem Van de Graaff accelerator has been installed on the Kumpula campus.

The enthusiasm among researchers in the Van de Graaff accelerator laboratory was tremendous. In the late 1950s and 1960s, the different research groups begged for time on it. Each week a detailed schedule was drawn up, and the accelerator was run regularly from 8 A.M. to 12 P.M. and sometimes around the clock. It usually was not run on Sundays and holidays, although sometimes it was. The physicists had long working days, some spending up to 78 hours per week in the laboratory, as shown on their schedules.

The Van de Graaff accelerator laboratory has had a strong influence on the development of physics in Finland. Students who wrote their theses in the laboratory have become physics professors and teachers in universities and colleges, engineering experts in technological universities and colleges, research fellows, and occupants of good positions in industry. Today nuclear physics is well established in Finland, and both basic

Fig. 15. The new accelerator laboratory on the University campus in Kumpula, which houses a 5-MV tandem Van de Graaff and was inaugurated in 1982. *Credit*: Department of Physical Sciences Collections.

and applied research is being carried out in several universities. This all can be traced to the pioneering work of the first Van de Graaff accelerator laboratory in Helsinki. Today, as noted above, there is a new 5-MV (million volt) tandem Van de Graaff accelerator laboratory on the Kumpula campus (figure 15), and cyclotrons are in operation in laboratories in Turku and Jyväskylä. These laboratories are now educating future generations of nuclear physicists in Finland. More broadly, the first Van de Graaff accelerator laboratory bequeathed generations of scientists to modern Finland who have been active in many areas of Finnish society and continue to inspire in Finnish citizens the tradition of open-mindedness that is characteristic of scientific and academic life.

Technical Education

The famous Finnish chemist Johan Gadolin (1760–1852) suggested, both during and after the era of Swedish rule, that practical schools in a total of fifteen different professions should be established, mainly for tradesmen and craftsmen. Students in them should learn about the properties of raw materials and how to manufacture finished products from them efficiently. The students should be at least 12 years of age on entrance, know how to read and write, and have a knowledge of Christianity and some knowledge of mathematics.

In 1835 an Imperial Decree was issued to establish a Technical Institute in Helsinki to educate future factory owners and workers. Its steering body was the Board of Manufacture whose first chairman and financial director was Lars Sacklén (1788–1870), the other Board members being Nils G. Nordenskiöld (1792–1866), chief director of the mining industry, Gustaf Gabriel Hällström (1775–1844), professor of physics, and Pehr Adolf von Bonsdorff (1791–1839), professor of chemistry. These people thus represented subjects that presumably would have a strong influence on the development of Finnish society. When Hällström retired in 1846, his place was taken by Johan Jakob Nervander (1805–1848), who also succeeded him as professor of physics. When Nervander died prematurely, his place was taken by Karl Backman (1805–1856), lecturer and director of the Helsinki Senior High School (Helsingfors Lyceum).

The Board of Manufacture issued a memorandum that laid out its plans for the organization and activities of the Technical Institute. It also specified that the director of the Institute should be appointed at an annual salary of 3,000 banco ass.,* a teacher of elementary mechanics and physics should be appointed at 1,200 banco ass., and a caretaker at 250 banco ass. This plan, however, was soon withdrawn and replaced by one that called for the establishment of technical schools in Helsinki, Turku, and Vaasa. Their students should possess the same entrance qualifications as above, and their educational programs should include courses in Christianity, calligraphy, linear and ornamental drawing, history and geography, technical subjects, and mechanics and physics. Regulations established in 1848 presumed that mechanics and physics would provide the foundation for all of the courses leading to the various professions.

The Technical School in Helsinki was located at Aleksanterinkatu 50, where it occupied eleven rooms on the first floor of the building and three more rooms in its basement, two for workshops and one for a blacksmith.[56] During its first ten years, from 1849–1858, it accepted 192 students, all of them very young: One was 10 years old, seven were 11 years old, forty were 12 years old, and the rest were hardly older. Consequently, they differed greatly in knowledge and maturity on entrance. Moreover, the teachers were paid according to the hours they actually taught in class, which resulted in a complete turnover every year. In particular, the teacher of mechanics and physics, although his subject was regarded as fundamental, had a badly equipped laboratory and was hired on an hourly basis, although this position was regularized in 1858 under the condition that he also would teach machinery, mechanical technology, and other subjects. The upshot was that very few students had either the ability or persistence to complete their courses and obtain their degrees. Of the 192 students who began their studies in 1849, only 29 had completed them by 1859.

In January 1859, Karl Leonard Lindberg, M.Sc., was appointed as teacher of physics. He had received a scholarship from the Board of Manufacture that had enabled him to study at the technical universities (Technische Hochschulen) in Karlsruhe, Zurich, and Berlin, and owing to his competence his appointment was made permanent in 1860. His teaching program during the first term included giving exercises in mechanics and other areas of physics, with their technical applications, for 4 hours per week. During the second term, he lectured on higher mechanics for 6 hours per week, and

* A banco ass. was a banknote in Swedish crowns that was issued by the Bank of Sweden; it was used concurrently with the ruble until 1848.

Fig. 16. The Polytechnical Institute (formerly the Polytechnical School) on Hietalahdentori square as seen in 1878. It soon had to be enlarged by adding more floors and wings to the building, and other buildings were attached to it. Today it is still used by the Technical Institute, but the Technical University has a large campus of its own in Otaniemi, Espoo. *Credit*: Photograph by Ernest Grönroos; Helsinki City Museum.

during the third term he lectured on the theory of viaducts and supports for 2 hours per week.

In the 1870s, the Technical High School was reorganized and renamed as the Polytechnical School. The teaching of physics then was separated from that of mechanics, with an additional teacher being hired in experimental physics, but his annual salary was only a meager 800 marks, so he hardly was expected to be a committed teacher. Then, in 1875, the Polytechnical School acquired a building of its own on Hietalahdentori square (figure 16), and the Imperial Senate made a special appropriation of 5,000 marks to purchase new physical instruments for it. The physical laboratory then was increased greatly in size to consist of a large hall and a large room on the ground floor of the building and two rooms in its basement which, however, had to be shared with the teachers of electronics, a subject that had begun to be taught in 1877.

In 1879, the Polytechnical School was renamed as the Polytechnical Institute, and physics then acquired the same status as the other major subjects of instruction. This led to the creation of a permanent position as Senior Teacher, which was held by August Fredrik Sundell (1843–1924) from 1879–1881 and by Karl Fredrik Slotte (1848–1914) thereafter.[57] Slotte was born in Nedervetil in Ostrobothnia, where his father was District Judge. He was first privately tutored at home and then attended elementary school for four years in Kokkola, a small town in western Finland. He graduated from the Swedish High School in Uleåborg (Uleåborg Svenska Lyceum) in 1867 and then enrolled in the Physico-Mathematical Section of the University in Helsinki, where he studied physics under Professor and Dean Adolf Moberg and mathematics under Professor Lorenz Leonard Lindelöf. He completed his Masters' degree in 1872, which included studies in chemistry, botany, philosophy, and Nordic history. Subsequently, he taught in the secondary school in Turku, formally through the academic year 1881–1882. However, in 1880–1881 he received the Pedagogical Travel Grant from the State, amounting to 3,000 marks, which enabled him to work in Gustav Wiedemann's laboratory in Leipzig where he studied the internal friction of some salt solutions. On his return from Leipzig, Slotte joined the teaching staff of the Polytechnical Institute in Helsinki, becoming Extraordinary Professor in 1897. The physics program by then included theoretical instruction during the first year and practical work during the second. In the section for machine construction, thermodynamics also was taught during the fourth year.

The number of personnel in the Polytechnical Institute increased gradually. In 1896 one assistant in physics was appointed in the laboratory, and in 1900 a second one was. In 1902–1903, the Polytechnical Institute underwent an extensive expansion, and in 1908 it was reorganized and renamed as the University of Technology. At that time, another teaching position in physics was added, and Slotte became Professor of Physics. He died in 1914 after teaching for 32 years in the highest technical institution of higher learning in Finland.

The Era of Expansion

For nearly two and a half centuries, physics in Finland was represented by only one person at a time, the professor of physics, first at the Academy of Turku and after 1827 at the Imperial Alexander University of Finland in Helsinki. A distinct expansion began only early in the 20th century. The Pippingsköld Chair of Applied Physics was established in 1895, and new universities and other institutions of higher education in which physics was part of their curricula were founded or revitalized, including the University of Technology in Helsinki in 1908, Åbo Academy (Akademi) in 1917, and the University of Turku in 1920. After Finland proclaimed its independence on December 6, 1917, the university in Helsinki was renamed as the University of Helsinki.[58]

At that time, physical research was concentrated in Helsinki and Turku, both lively university cities. Until the middle of the 20th century, Finnish experimental physicists concentrated primarily on phenomena that exploited techniques in X-ray and thermal physics. One of the pioneers in X-ray physics was Jarl A. Wasastjerna (1896–1972), who was the Pippingsköld Professor of Applied Physics from 1925 to 1946, and who supervised 14 doctoral dissertations in this field.[59] Under his leadership and that of his successors, Paavo E. Tahvonen (1904–1981) and Kaarle Kurki-Suonio (b. 1933), X-ray physics was developed into a vigorous field of research that still flourishes today. Collaborations have been established with several international laboratories, and diffraction experiments, studies of inelastic-scattering processes, and the utilization of synchrotron radiation for angiography and bronchography are ongoing.[60]

After World War II, theoretical physics developed greatly in Helsinki and Turku owing to the contributions of Hjalmar Tallqvist (mechanics), Yrjö Ahmavaara (field theory), and Gustav Järnefelt (astronomy and general theory of relativity). Then, with

Fig. 17. Kalervo V. Laurikainen (1916–1997) Professor of Nuclear Physics and later of Elementary Particle Physics from 1960–1979. *Credit*: Photograph by Nyblin; Department of Physical Sciences Collections.

the appointment of Kalervo V. Laurikainen (1916–1997) to a new chair in nuclear physics, theoretical nuclear and elementary-particle physics acquired a strong base in Helsinki. Laurikainen (figure 17) and his colleagues established close contacts with the high-energy laboratories in Geneva (CERN) and Dubna, and Laurikainen led the effort for Finland to become first an observing member and then a full member of CERN. Today there are groups working in theoretical nuclear physics, elementary-particle physics, high-energy physics, and space physics that maintain close contact with physicists in the Helsinki Institute of Physics, and internationally with physicists at CERN in Geneva, DESY in Hamburg, Nordita in the Scandinavian countries, and several European universities.

In experimental physics, Nils Fontell, who was Professor of Physics from 1942–1968, was an expert in thermodynamics; he carried out precision calorimetric studies on molecular heats and wrote a thermodynamics textbook that was used by students for years. Many of his students followed in his wake and carried out related experiments in the 1970s. Fontell was the last head of the physics department who was privileged to live in the large separate building close to the main building of the Physical Institute at Siltavuori; when he retired this building was converted into laboratory space. Much earlier, in 1941, Lennart Simons, who was appointed to a professorship that was designated for a Swedish-speaking physicist, led the effort, as we have seen, to establish the Van de Graaff Accelerator Laboratory after World War II.

Between 1958 and 1968, a vigorous expansion in higher education began, and the number of professors of physics at the University of Helsinki increased. In addition, several other Finnish universities were established in the 1960s and developed physics programs that often were staffed by physicists educated at the University of Helsinki. Thus, Mårten Brenner went to Åbo Academy (Akademi) and Juhani Kantele went to the University of Jyväskylä, and both of these universities subsequently founded accelerator laboratories and nuclear-research programs. Today these new universities have their own research projects, and their own graduates contribute to the development of physical research in various cities in Finland.

In Helsinki, there was an increase in the number of professors of physics (some of whom were appointed for renewable five-year terms), whose teaching and research responsibilities often were defined more precisely, which opened up new fields of research in the physics department in a relatively short period of time. In this way, the physics department has maintained its position as a leading research institution in Finland with a wide network of international contacts, allowing professors and their students to profit from them. Leading research in X-ray physics, nuclear physics, materials physics, elementary-particle physics, high-energy physics, cosmology, and environmental physics is being carried out today, assuring that the University of Helsinki will remain prominently on the international map of physics.

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Institute of Biomedicine
University of Helsinki
P.O. Box 63
SF-00014 University of Helsinki, Finland
e-mail: peter.holmberg@helsinki.fi