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Physics in Perspective

The Physical Tourist

Geneva: From the Science of the Enlightenment to CERN*

Jan Lacki**

John Calvin (1509–1564) founded a College and Academy in Geneva in 1559, the latter of which, through the efforts of many of its scholars, was finally declared to be a genuine university, the University of Geneva, in 1872. Meanwhile, thanks to the outstanding achievements of the rich, patrician Genevan scientists, in particular during the 18th century, Geneva secured a prominent place in European learned society. With the appointment of Charles-Eugène Guye (1866–1942) to the University of Geneva in 1900, Genevan research entered resolutely into 20th-century physics, particularly relativity, and continued to gain momentum before and after the Second World War when, in 1953, Geneva was chosen as the site of one of the most prestigious scientific laboratories in the world, CERN. I sketch these developments, pointing out many of the locations where they occurred in Geneva.

Key words: Geneva College and Academy; Geneva Observatory; University of Geneva; Institute of Physics; Museum of History of Science; CERN; John Calvin; Carl Vogt; Jean-Robert Chouet; Jacques-André Mallet; Emile Gautier; Horace-Bénédict de Saussure; Pierre Prévost; Gaspard de la Rive; Auguste de la Rive; Charles-Eugène Guye; Albert Einstein; Ernest C.G. Stueckelberg; physics; astronomy; history of physics; scientific instruments; theory of relativity; quantum theory.

Introduction

Most people probably associate physics in Geneva, Switzerland, with CERN, one of the most prestigious scientific laboratories in the world. Some who are historically inclined, however, will know that Geneva has a glorious scientific past, for during the Enlightenment of the 18th century it witnessed a burst of scientific activity that was unmatched by hardly any other European city of comparable size.[1] Genevan scientists such as Abraham Trembley (1710–1784), Charles Bonnet (1720–1793), Jean-André Deluc (1727–1817), Marc-Auguste Pictet (1752–1825), Horace-Bénédict de Saussure

* For an interactive map of Geneva, see the website <www.ville-ge.ch/en/cartes/>.

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(1740–1799), Pierre Prévost (1751–1839), and their peers were typical representatives of 18th-century men of science who achieved, without any institutional support, scientific greatness. However, as science became more and more professionalized in the 19th century, Geneva's learned institutions proved to be outdated and could not keep up with the increased pace of European science. The legacy of the rich, patrician 18th-century Genevan scientists could not be extended without fundamental institutional changes.

Calvin's College and Academy

In 1559 John Calvin (1509–1564) founded a College and Academy in Geneva, but it took three more centuries, until 1872, before Carl Vogt (1817–1895), a German refugee who became an outspoken advocate on the Genevan political and academic scene, succeeded in having Calvin's Academy declared a genuine university, the University of Geneva, with himself as its first Rector.[2] He finally made the dream of many liberally minded Genevan scientists and intellectuals since the 17th century come true.

Calvin had conceived his College and Academy as two successive institutions, with students pursuing their primary education in French, Latin, Greek, history, rhetoric, and catechism between the ages of seven and fifteen in the College and then being admitted into the Academy.[3] Both were devoted to the education of Geneva's professional elite, with special emphasis placed upon the training of clergymen, who were required to minister to its growing protestant community. Calvin and his counselors promoted higher education as essential for spiritual progress and leadership, but did not insist that science be taught. The Academy began with four chairs (Theology, Greek, Hebrew, Philosophy) and despite an intense effort by Théodore de Bèze (1529–1605), Calvin's successor and first Rector of the Academy, to extend its teaching to Law and Medicine, only the former achieved a precarious stability a decade after its founding.* The first dedicated teaching in science had to wait until the beginning of the 18th century with the establishment of the first chair of mathematics in the Academy in 1724 and the first chair of experimental philosophy in 1737, both of which were manifestations of the progressive conviction that science could serve religion through the study of Nature, the glorious creation of God.** Then, as the influence of Cartesianism began to weaken on the European continent, Geneva became an early stronghold of Newtonianism whose representatives reexamined the relationship of science to religion. Much of this spirit guided the endeavors of 18th-century Genevan scientists.

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* The tragic St. Bartholomew's Day massacre in France (1572) caused a massive influx of protestant refugees to Geneva with many first-rate scholars among them. Some were hired by the Academy and greatly helped to promote the teaching of law and the humanities.

** The slowness in the enlargement of the Academy's teaching was not only due to the resistance of the clerical authorities. In its early stages, Geneva's finances were in quite bad shape, which not only prevented the hiring of additional professors, but sometimes led to the suppression or at least temporary suspension of some teaching which, when eventually renewed, often had its name changed. This lack of continuity persisted in the 18th and 19th centuries; it makes the evolution of the teaching of science in Geneva quite difficult to reconstruct chronologically.

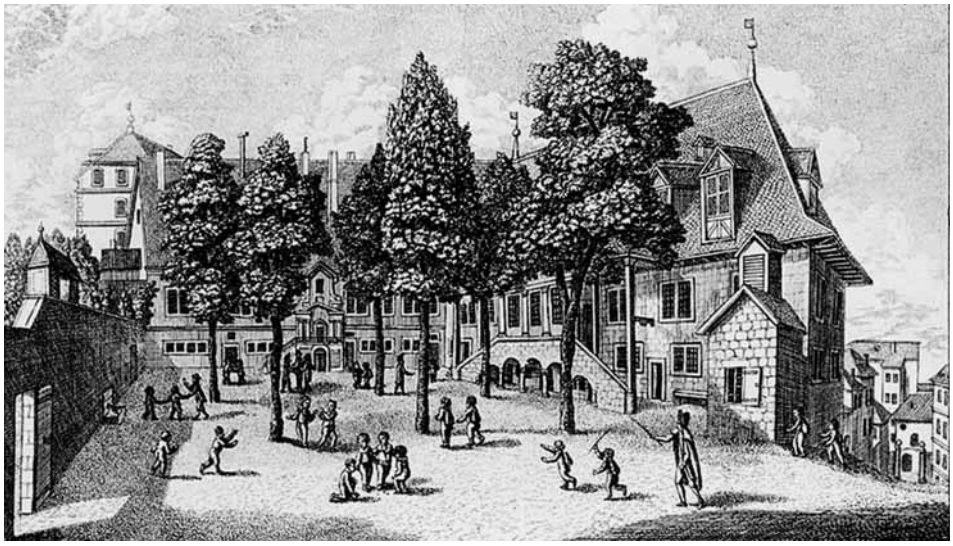

Fig. 1. The Collège and Academy as seen in an engraving of 1822 by Pierre d'Escuyer (1749–1834). *Credit*: Centre Iconographique Genevois, coll. Bibliothèque Publique et Universitaire, 29 P Rig. 599; also reproduced in Borgeaud, *Histoire*, Vol. 2 (ref. 2), p. 7.

The original buildings of Calvin's College and Academy can be seen today (figures 1 and 2); they are located on the edge of Geneva's Old Town on a hill that is surrounded by modern edifices. They house today the *College Calvin*, one of the most prestigious secondary schools in Geneva. The oldest building of the 19th-century modern university is located at the foot of the opposite side of the Old Town hill, in the *Parc des Bastions* where statues of Calvin and Bèze contemplate this offspring of their efforts. The rest of the University's buildings are distributed elsewhere throughout the city.

The roots of the transformation of Calvin's rigid Protestant Academy into a more liberal institution of higher education can be traced to the efforts of Jean-Robert Chouet (1642–1731), a descendant of a well-known family of Genevan printers.[4] Chouet held the chair of philosophy at the Academy from 1669 to 1686. As a Cartesian, he propagated a spirit of modernity in his teaching, but managed not to bring it into conflict with theological matters. We owe to him the introduction of the experimental method into Geneva: Each Wednesday he carried out experiments in public that attracted large audiences. Chouet's chair was one of nine at the Academy whose occupants offered a two-year curriculum in ancient languages and philosophy, which was then followed by two more years of specialization in law or theology. Most of Geneva's professional elite (the population of Geneva was then about 20,000) was educated at the Academy. By the early 18th century, the strong grip that the clerical authorities exerted on its curriculum had eased: A typical student would first attend lectures for two years on French, Latin, Greek, and history in the Auditorium of Humanities, then for two years on mathematics, science, and philosophy in the Auditorium of Philoso-

Fig. 2. The College building as it appears today. Photograph by the author.

phy, and finally for four years on theology and law in the Auditorium of Theology, with an examination at the end of each stage.

When Chouet gave up teaching in 1686 to pursue a successful career as a statesman, he tried to use his political influence to promote the transformation of the Academy into a full-fledged university. He attempted, in particular, to expand the curriculum of the Academy but was only partly successful, because that implied an increase in secular subjects, which the *Vénérable Compagnie des Pasteurs*, the highest clerical authority in the city, opposed. Nevertheless, in 1701–1704 he managed to officially open the Academy to the teaching of science, which he saw as helping to promote a more liberal theology based upon reason rather than dogmatic religious faith.

Chouet's efforts resulted only in the introduction of the teaching of mathematics (geometry) in 1704 by Etienne Jalabert (1658–1724) who, however, gave up teaching mathematics in 1713.* A regular chair in mathematics was finally established in 1724, with a unique twist: The Academy's magistrates hired to fill the new chair not with

* The chair of mathematics was at first only honorary (without salary), so as soon as he could Jalabert exchanged it for the regular chair of philosophy. As a rule, many chairs created later in the sciences were initially honorary, and only later were transformed into regular ones.

one but two young and brilliant mathematicians, the close friends Jean-Louis Calandrini (1703–1758) and Gabriel Cramer (1704–1752), with the understanding that they would share its duties – and its salary.[5] The magistrates also required that each of the two mathematicians would spend two or three years traveling, and while one was away, the other would be responsible for the full list of the chair's duties and receive its full salary. This tandem arrangement worked quite well: The courses they offered triggered the careers of Charles Bonnet (1720–1793) and Etienne Jalabert's son Louis-Jean (1712–1768). This was the beginning of a spectacular succession of Genevan scientists. The naturalist Bonnet achieved considerable fame for his important discovery of parthenogenesis in 1740, while his relative Abraham Trembley (1710–1784), another celebrated naturalist, became famous for his experiments on hydra and their regeneration. The natural philosopher Louis-Jean Jalabert became the first holder of a (still honorary) chair in experimental physics at the Academy in 1737 and thus built upon his father's legacy. He gained considerable recognition for his researches on electricity, which stimulated a mild rivalry with the Abée Jean-Antoine Nollet (1700–1770), as witnessed by their extensive correspondence between 1739 and 1760.

The Geneva Observatory

Astronomy as well as experimental physics was introduced into the Academy in the 18th century.[6] In 1739 Louis-Jean Jalabert called for the creation of an astronomical observatory, which attracted some attention, since the following year the *Rapport de l'Académie* carried an acknowledgment of its potential benefits. Still, it took more than three decades, until 1772, before Jacques-André Mallet (1740–1790) obtained authorization to erect, partly at his own expense, the first observatory on the *Bastion de St-Antoine*, facing the College and Academy buildings. Mallet's success in persuading the authorities to authorize its construction stemmed in part from the great interest generated at the time by the two transits of Venus, which had occurred earlier in 1761 and 1769, and which had prompted expeditions to Lapland. Mallet himself took part in the second one, accompanied by his friend Jean-Louis Pictet (1739–1781).

Mallet not only supported the construction of the observatory financially, he also purchased the best instruments for it over the years. Together with his student Marc-Auguste Pictet (1752–1825) and Jean Trembley (1749–1811), Mallet carried out numerous observations of eclipses, the satellites of Jupiter, comets, sun spots, and the like. His contributions to astronomy secured him a respectable place among European astronomers, and he was elected as a Corresponding Member of the Paris *Académie des Sciences* in 1772.

After Mallet's death in 1790, Marc-Auguste Pictet succeeded him as Director of the Geneva Observatory and held that position until his retirement in 1819. He continued Mallet's astronomical observations, but since he was at least as much a physicist as an astronomer, he also promoted meteorological and chronometrical investigations. Eventually, in 1842, the mission of the observatory was officially extended to encompass chronometry and the development of control techniques in the service of Geneva's clockmaker enterprises.

Fig. 3. The Geneva Observatory, erected in 1830. The St. Pierre Cathedral where Calvin preached is in the background. *Credit*: Observatoire de Genève.

In 1821 Jean Alfred Gautier (1793–1881) succeeded Pictet as Director of the Geneva Observatory and immediately began to modernize it. In 1830, Guillaume Henri Dufour (1787–1875), a talented engineer and scientist who later became a brilliant general,* was commissioned to supervise the construction of a new observatory (figures 3 and 4). It no longer exists, but its location, which was in front of the present *Musée d'Art et d'Histoire* at *2 Rue Charles-Galland*, is not far from the College and Academy and still bears the name *Promenade de l'observatoire*.

When Gautier's declining health obliged him to retire as Director of the Geneva Observatory in 1839, he was succeeded by his student Emile Plantamour (1815–1882), who held that position until his death and contributed greatly to its scientific reputation. Then, in 1883, another Gautier, Emile (1822–1891), succeeded Plantamour as Director and initiated research in a new domain, physical astronomy. He used recent spectroscopic techniques to study the solar spectrum, and through his researches joined the ranks of the pioneers who founded the discipline of astrophysics.

In 1966 a modern observatory was opened in Sauverny at the extreme eastern part of the Geneva canton on the French border.** It is shared with the *Laboratoire d'astrophysique* of the Swiss Federal Institute of Technology (*École Polytechnique Fédérale*) in Lausanne, and continues its tradition of excellence as witnessed by the world-renowned discovery by Professor Michel Major (b. 1942) and his team of the first planets outside of our solar system.

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* An equestrian statute of Dufour is in the *Place Neuve* at the foot of the Old Town hill (see figure 7 below).

** See its website <www.unige.ch/sciences/astro/an/>.

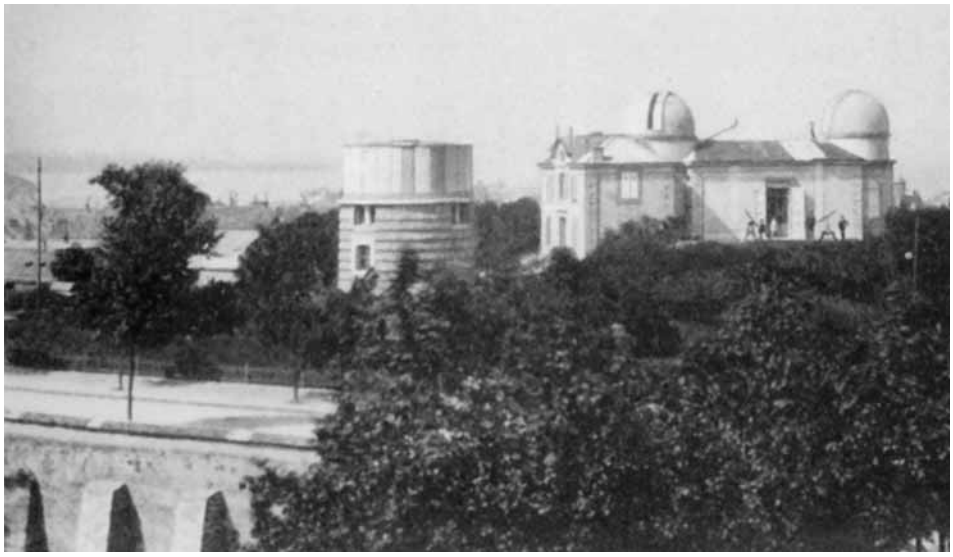

Fig. 4. Another view of the Geneva Observatory. *Credit*: Observatoire de Genève; also reproduced in Golay, "L'Astronomie" (ref. 6), p. 79.

Horace-Bénédict de Saussure and His Instruments

When Marc-Auguste Pictet succeeded Mallet as Director of the Geneva Observatory and Lecturer in Astronomy at the Academy in 1790, he had already been lecturing on physics and philosophy since 1786, occupying the chair of philosophy that was vacanted following the retirement of another illustrious Genevan scientist, perhaps the best known one of all, Horace-Bénédict de Saussure (1740–1799).[7] Horace-Bénédict followed in the footsteps of his father Nicolas (1709–1790), a famous agronomist, and extended decisively the extraordinary de Saussure dynasty of naturalists. Since Nicolas preferred to live with his family in the Conches countryside south of Geneva, his young son soon acquired his devotion to the observation of Nature, which he reinforced later in Frontenex, another countryside family residence. Horace-Bénédict's own son Nicolas-Théodore (1767–1845), a mineralogist and geologist, extended the dynasty still further, as did his grandson, Henri Louis Frederic (1829–1905), also a mineralogist, but his great-grandson Ferdinand (1857–1913) eclipsed the fame of all of his ancestors with his renowned research in linguistics.

Horace-Bénédict de Saussure was a typical representative of the Enlightenment, carrying out researches ranging from his first ones in botany, which were triggered by his uncle Charles Bonnet (1720–1793) and by a memorable encounter with the great Swiss naturalist Albrecht von Haller (1708–1777), to his later ones in geology, meteorology, and electricity. Suspicious about premature theorizing and speculation, he excelled in experimentation and observation: He preferred to collect facts patiently using instruments that he often designed and constructed himself. He exhibited an attitude of devoted inquiry into Nature's wealth of phenomena that was something of a

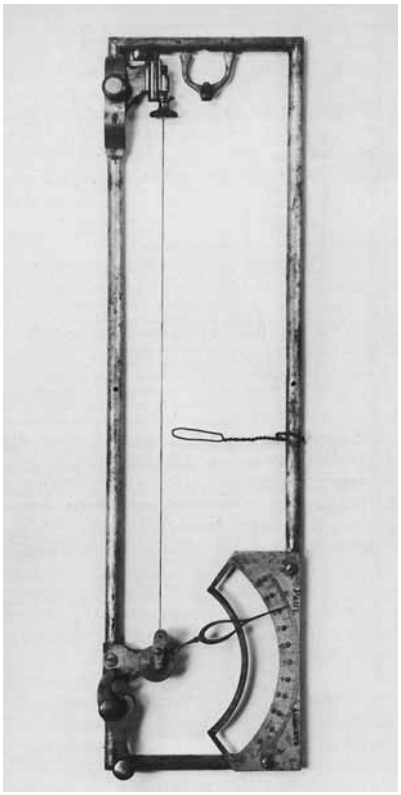

Fig. 5. Horace-Bénédict de Saussure's hygrometer of 1783. *Credit*: Museum of History of Science, Geneva.

hallmark of 18th-century Genevan scientists, be they committed to natural theology or to natural history. Some were indeed more speculative, such as Nicolas Fatio de Duillier (1664–1753), Georges-Louis Lesage (1724–1803), and Pierre Prevost (1751–1839), but the specifically 18th-century Genevan science is represented best by the naturalists, who embraced experimentation and observation and opposed vain speculation.[8] In any case, while no Genevan scientist rose to the level of Galileo, Descartes, or Newton, together they contributed significantly to the enormous harvest of scientific facts in line with the new standards of scientific observation and experimentation that had been defined by the founders of the Royal Society of London and the Paris *Académie Royale* in the second half of the 17th century.

The range of instruments that de Saussure invented or perfected is impressive and reflects his broad scientific researches.[9] They include a magnetometer for measuring terrestrial magnetism and a heliothermometer for measuring solar heat (1774), a hygrometer for measuring the humidity of air (1783), an electrometer for measuring atmospheric electricity (1785), an anemometer for measuring wind velocity (1788), a cyanometer (*cyanomètre*) and a diaphanometer (*diaphanomètre*) to measure the blue

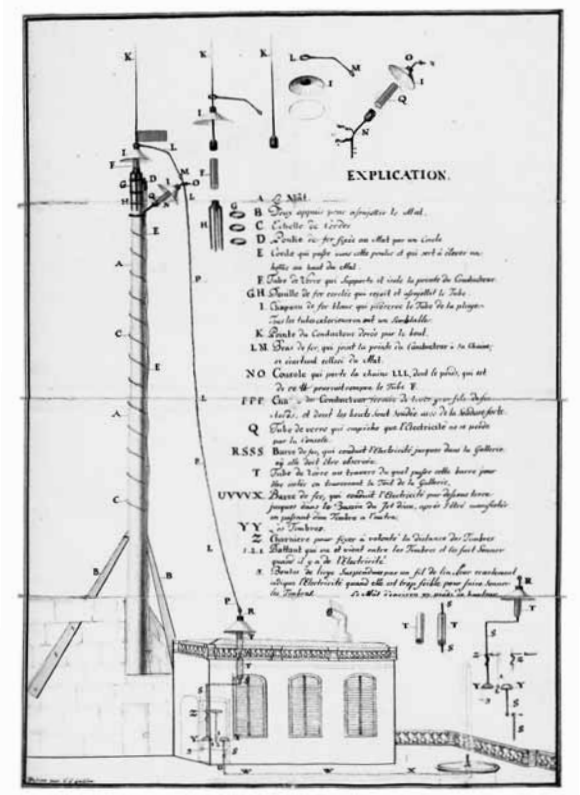

Fig. 6. The design of Horace-Bénédict de Saussure's lightning rod. *Credit*: Bibliothèque Publique et Universitaire, Archives Saussure, no. 66.6; also reproduced in Speziali, "La Physique" (ref. 7), p. 127.

color of the sky and its transparency (1788), a photometer to measure the chemical effects of solar light (1788), a fusiometer (*fusiomètre*) to measure the heats of fusion of substances (1794), and a sclerometer to determine the hardness of substances (1795). His hygrometer (figure 5) is probably his best-known instrument, while his strangest one is probably his cyanometer. All bear witness, however, to his strong desire to quantify the phenomena of Nature in an attempt to uncover their underlying order.

De Saussure displayed his scientific curiosity and pioneering spirit in his researches on electricity. In 1766 he published a treatise, *Dissertatio physica de electricitate*, in which he argued that the one-fluid theory of electricity propounded by the American polymath Benjamin Franklin (1706–1790) was superior to the two-fluid theory of the Abée Jean-Antoine Nollet (1700–1770). Two years later, de Saussure met Franklin personally in London, and after he returned to Geneva, he erected a lightning rod on the wall surrounding his Old Town mansion (1771), which he later mounted on its roof (1776). This was the first lightning rod ever erected in Switzerland (figure 6), and we are told that his neighbors greeted his endeavor in a rather unfriendly fashion, fearing that the device would attract celestial trouble. De Saussure's residence is one of an

Fig. 7. A view of the *Place Neuve* with the statue of Henri Dufour and in the background (center) the *Tertasse* mansion of Horace-Bénédict de Saussure. Photograph by the author.

impressive group of edifices that dominate the *Place Neuve* on the edge of the Old Town (figure 7): From the *Place Neuve* follow the *rue de la Tertasse* to locate his residence at *1 rue de la Tertasse*, which has a commemorative plaque on it. He owed this residence to his marriage, in 1765, to Albertine Amélie Boissier, a daughter of one of the wealthiest men in Geneva. Thanks to his marriage, de Saussure could also enjoy the lavishness of a gorgeous countryside residence in Genthod, a charming little spot on the shore of Lake Geneva.

Geneva Museum of History of Science*

The Geneva Museum of History of Science is housed in the palatial *Villa Bartholoni* (figure 8) at *128 Rue de Lausanne* in the *Parc Perle du Lac* on the western shore of Lake Geneva north of the city center and close to the *Jardin Botanique*. After seeing its extensive collections, the visitor will be able to enjoy, weather permitting, a breathtaking view of Mont Blanc some eighty kilometers to the south. In addition to his other achievements, Horace-Bénédict de Saussure was a pioneer in the scientific study of mountains: As a teenager he began hiking in the nearby mountains; then, beginning in

* See its website <www.ville-ge.ch/culture/mhs/>.

Fig. 8. The Villa Bartholoni, which houses the Geneva Museum of History of Science. *Credit*: Museum of Art and History (*Musée d'Art et d'Histoire*), Geneva.

1760 he went on extended annual expeditions in them; and from 1774 he made several expeditions in the Alps. Finally, in 1787, accompanied by eighteen servants carrying a load of scientific instruments, he became one of the first to climb Mont Blanc to measure for a few hours the extreme physical conditions at its summit. He published an account of his expeditions and observations in his celebrated four-volume *Voyages dans les Alpes* between 1779 and 1796; he regarded this work as a prelude to his monumental *Théorie de la Terre*, which, however, he was unable to finish before his death in 1799: The turbulent events surrounding the French Revolution did not help his declining health.*

Many of de Saussure's instruments are on display in the Museum of History of Science. In fact, his instruments, which his descendants donated to the City of Geneva, formed the initial core of a collection that grew rapidly as the descendants of other famous scientists followed their example. In 1963, following intense lobbying by the *Association pour le Musée d'Histoire des Sciences* (which had been founded for that purpose a decade earlier), the municipal authorities decided that the former palatial mansion of the bankers Bartholoni should serve as its permanent exhibit place, thus establishing the present Museum. François Bartholoni (1796–1881) had constructed

* There was recurrent social unrest in Geneva during the 18th century, but it did not seriously affect the local oligarchy. The situation changed drastically in 1792, when revolutionary committees seized power, effectively ending a centuries-old political tradition. Shortly thereafter, an even more drastic event occurred when, in 1798, French forces occupied Geneva, ending its independence, and annexing it to France.

the mansion in 1829–1830; its architect, the Parisian Félix-Emmanuel Callet (1791–1854), was a fine connoisseur and admirer of Italian architecture, which accounts for the neoclassical Palladian style of this magnificent building. After some changes in its proprietors, the Genevan authorities finally took possession of it early in the 20th century.

De Saussure's scientific instruments are located in a room on the ground floor of the Museum, where many of his personal effects, including his jacket, an impressive pair of sunglasses, and boots with crampons that he used to climb Mont Blanc, are also on display. In an adjoining room, some of the finest instruments that Mallet purchased for the Geneva Observatory can be admired, including a meridian telescope (*lunette méridienne*) and an achromatic telescope (*lunette achromatique*) made by the English instrument maker John Dollond (1706–1761), and a high-precision clock made by the French clockmaker Jean-André Le Paute (1720–1788). Another room houses meteorological instruments; especially noteworthy is the beautiful shock-proof barometer that Jean-André Deluc (1710–1784) designed and that de Saussure took on his ascent of Mont Blanc. Yet another room is devoted to microscopy, where the microscope that Abraham Trembley (1710–1784) used in his famous observations of polyps is on display.

On the first floor of the Museum is an impressive collection of instruments for studying electrical phenomena, which, since Jean Jalabert's early studies, were much investigated in Geneva. When new avenues of research opened up following the invention of the voltaic pile by Alessandro Volta (1745–1827) in 1800, Genevan scientists went resolutely ahead, especially members of the de la Rive family,[10] another of Geneva's most distinguished scientific dynasties. [Charles-]Gaspard de la Rive (1770–1834) was professor of chemistry at the Academy but was quickly drawn to the study of electricity and founded the dynasty that continued with his son Auguste de la Rive (1801–1873) and grandson Lucien de la Rive (1834–1924). Gaspard de la Rive's experiments and instruments (especially his impressive voltaic pile) established his scientific reputation and attracted to Geneva such illustrious scientists as André-Marie Ampère (1775–1836), François Arago (1786–1853), and Humphry Davy (1778–1829). Davy, accompanied by his young secretary Michael Faraday (1791–1867), visited de la Rive in 1814 during a tour of the continent.* Arago visited de la Rive for the first time in 1820 at his country mansion, where he witnessed the experiment that Hans Christian Oersted (1777–1851) had just carried out in his discovery of electromagnetism. Ampère visited de la Rive at least twice. His second visit in 1822 at de la Rive's country mansion is particularly noteworthy: Assisted by Gaspard's son Auguste, Ampère observed electromagnetic induction but did not recognize its significance – which Faraday did nine years later in 1831. Two years earlier, Faraday's mentor Davy died in Geneva and was buried in the *Cimetière de Plainpalais*,** the entrance to which is at *10 rue des Rois*, where many celebrated Genevan statesmen and scientists are buried, including John Calvin, Horace-Bénédict de Saussure, the celebrated botanist Augustin-

* Faraday retained a vivid and grateful lifelong memory of his meeting Gaspard de la Rive, as witnessed by his correspondence of the period with him.

** For a photograph of Davy's tombstone, see Speziali, "La Physique" (ref. 7), p. 147.

Pyramus de Candolle (1778–1841), Guillaume-Henri Dufour (1787–1875), as well as, more recently, Jean Piaget (1896–1980).

In 1823 Auguste de la Rive succeeded Pierre Prevost (1751–1839) as Professor of General Physics at the Academy, and two years later he succeeded Marc-Auguste Pictet (1752–1825) as Professor of Experimental Physics.* Although de la Rive's predecessors carried out significant experiments on heat exchange, he did not pursue these investigations but continued his father Gaspard's on electromagnetism. He had assisted him in his researches already as a student, but soon conceived and carried out his own experiments, first in his father's laboratory at his residence in Présinge, and later in his own laboratory in his house at *80 rue de l'Hôtel de Ville* in the heart of Geneva's Old Town. He is best remembered today for his invention of electroplating and for his studies of the aurora borealis. His *Traité d'electricité théorique et expérimentale*, which he published in three volumes in 1854, 1856, and 1858, became a classic on the subject.

In the spring of 1889, less than two years after Heinrich Hertz (1857–1894) had confirmed the existence of Maxwell's electromagnetic waves, Auguste de la Rive's son Lucien, assisted by his friend Edouard Sarasin (1843–1917),** repeated Hertz's experiments,[11] using the facilities of the *Société pour la construction des instruments de physique* (later the *Societé des instruments de physique*, SIP), a company dedicated to the making of scientific instruments that was founded by, among others, Lucien's father Auguste.[12] The SIP facilities are enclosed by the *rue Gourgas* and the *rue des Bains*,*** a few blocks from the *Quai Ernest-Ansermet* where today's Institute of Physics is locat-

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* In the first three decades of the 19th century, the number of chairs in science increased substantially. From three in the middle of the 18th century (mathematics, experimental physics, astronomy), they increased to twelve by around 1825 (general and experimental physics, pure and applied mathematics, general and applied chemistry, astronomy, rational philosophy, analytical mechanics, zoology, botany and anatomy and medicine). Further, a new university rule was promulgated in 1825 that put the four faculties (theology, sciences, humanities, law) on an equal footing and reorganized their curricula. At this time of much less specialization than today, the appointment of new professors was accompanied by a redistribution of chairs that were better suited to their interests; see Geisendorf, *L'Université* (ref. 2), pp. 166–207.

** Sarasin enjoyed a regular correspondence with Hertz, and when Hertz visited Geneva at the end of March 1892, Sarasin served as his host at his residence in Grand-Saconnex (today close to the Geneva airport), of which he was for years mayor. For Hertz's visit, see Johanna Hertz, *Heinrich Hertz: Erinnerungen Briefe Tagebücher* (Leipzig: Akademische Verlagsgesellschaft, 1927), p. 241; *idem*, *Heinrich Hertz: Memoirs Letters Diaries*, Second English Edition (San Francisco: San Francisco Press, 1977), p. 323.

*** The SIP building at *10 Rue des Vieux-Grenadiers* (where it was located before the society moved to an industrial park outside of Geneva) was the site of the mansion of one of the SIP founders, Marc Thury (1822–1905), who in 1862, at the instigation and under the patronage of Auguste de la Rive, created a workshop for the construction and repair of scientific research apparatus and instruments. After much initial hardship, the SIP became over the years a world-renowned manufacturer of scientific instruments, measuring devices, and machines, in particular its famous pointer machine (*machine à pointer*). Its bankruptcy in 2005 was a cause of much emotion, as many saw it as a symbol of the end of Geneva's outstanding technological tradition and as confirming the ineluctable decline of Geneva's industrial vitality. The building is a fine example of industrial architecture; it now houses the Geneva Museum of Modern and Contemporary Art and also the workshop of the Institute of Physics of the University of Geneva.

ed (see below). Lucien and Edouard continued their experiments until 1893. Later, Lucien de la Rive published studies on gravitation, electron theory, Maxwell's equations, and even relativity at an advanced age.

The 20th Century: Charles-Eugène Guye

With the work of Lucien de la Rive, we have entered the 20th century, during which physics in Geneva gained increased momentum. A telling symbol of this new surge is that when de la Rive received an honorary doctoral degree from the University of Geneva in 1909 (he never held a university position), the young Albert Einstein (1879–1955) also received one – the first one that he ever received – on the same occasion. The man behind this early recognition of Einstein was another remarkable Genevan physicist, Charles-Eugène Guye (1866–1942).[13]

Guye received his Ph.D. degree from the University of Geneva in 1889 with a thesis on the refractive properties of quartz that he wrote under the direction of Charles Soret (1854–1904). After an unsuccessful application to teach at the *College*, Guye left Geneva in 1891 and moved to Zurich. In 1894 he was appointed to a professorship at the Federal Institute of Technology (*Eidgenössische Technische Hochschule*, ETH) in Zurich, where he carried out various researches on alternating currents, polyphase generators, and other aspects of electrical technology. Six years later, the chair of experimental physics at the University of Geneva became vacant following the retirement of Soret – but it was not offered to his former student Guye: It was instead proposed to the renowned Parisian physicist Pierre Curie (1859–1906), who agreed to accept it under exceptionally favorable conditions, but at the very last minute changed his mind, apparently because he and his wife Marie (1867–1934) did not wish to give up their researches on radium in Paris.[14] In any case, Curie's last-minute refusal caused a great deal of disappointment and resentment in Geneva, and the position was then offered to Guye, who accepted it.

Guye's appointment proved to be fortunate. In addition to continuing his earlier researches and pursuing others on magnetic hysteresis, electrical arcs, internal friction of matter, and gas discharges at high pressure, he moved resolutely to the frontier of research on electrodynamics and relativity. Thus, between 1907 and 1915 he carried out a series of experiments on the variation of the mass of cathode rays (electrons) with their velocity, initially to compare the rival rigid-electron theory of Max Abraham (1875–1922) to the deformable-electron theory of Hendrik A. Lorentz (1853–1928) and Einstein. Earlier, Walter Kaufmann (1871–1947) had erroneously concluded from his pioneering experiments on accelerated beta particles (electrons) that Abraham's theory was correct, but Guye established in the most precise way the validity of the Lorentz-Einstein theory. He thus became an early proponent of Einstein's theory of special relativity, and in 1909, when the University of Geneva celebrated its 350th anniversary and the City of Geneva the 400th anniversary of Calvin's birth,[15] Guye succeeded in securing a place for Einstein among the numerous scientists who would receive honorary doctoral degrees on this occasion. The minutes of the Faculty Council reveal that it wished to maintain a balance of scientists from the various countries, so at its meeting on May 4, 1909, more Germans scientists were added, including the

prominent Göttingen physicist Woldemar Voigt (1850–1919) and the prominent Leipzig physical chemist Wilhelm Ostwald (1853–1932). Guye then proposed to also add "Mr Einstein," who was identified laconically as a "physicist from Bern."[16]

After Guye published the final results of his experiments, Einstein repaid Guye's compliment, writing several letters to Guye that are preserved in the Museum of History of Science, two of which praised Guye's experiments as being the most precise at the time.[17] Guye carried out his experiments in two stages with the help, successively, of two of his students, Simon Ratnowsky and Charles Lavanchy.[18] The cathode-ray tubes he used are enclosed in a wooden casket and are preserved in the Museum of History of Science (figure 9).

Guye carried out these experiments in the central building of the University in the *Parc des Bastions* (figure 10). This building, together with its two wings, was inaugurated in 1871 to house the growing activities of the Academy, which for a long time had been beset by a serious lack of space and geographical unity.* One of the wings, today called the *Aile-Jura*, was designated to house the Genevan science and natural history collections (the *Musée académique*),** the other one to house the central Library (the *Bibliothèque Publique et Universitaire*),[19] which is still located there today. The collection of physical instruments (*Cabinet de Physique*), which comprised instruments that had been donated to, or acquired by the academic authorities, was moved into the basement of the central building, while the physical laboratories were located on its first floor. This space soon proved to be too small to accommodate a full-scale experimental program, however, and in 1880 when chemistry moved into its own building at *22 boulevard des Philosophes* (which is easily recognizable owing to the massive chimney on its roof), the experimental-physics laboratory was moved into the vacated space in the basement.

Guye gained considerable fame for his experiments and consequently was appointed to serve on numerous commissions and committees. Among these were the Scientific Committees of the fifth, sixth, and seventh Solvay Congresses of 1927, 1930, and 1933 in Brussels, the last one of which he was unable to attend owing to ill health. (Einstein also did not attend the seventh Solvay Congress, because by the time it was held

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** Since the time of Calvin, the Academy lectures were given in various religious premises and, after 1819, also in the premises of the beautiful *hôtel particulier* at *11 Grand'Rue* in the Old Town, which during the French occupation had housed the *Préfécture* of the *Département du Léman* (whose capital was Geneva). When Geneva regained its independence in 1813 and soon thereafter was integrated into the Swiss Confederation, the Rector of the Academy, Henry Boissier (1762–1845), reclaimed this building for the Academy and designated part of it for the teaching of the sciences and for housing the scientific instruments and collections, thus forming the *Musée académique*. His actions resulted in establishing the Faculty of Science of the Academy there in 1818.

** The initial core of the scientific collections was Boissier's own *cabinet d'histoire naturelle*, which then expanded substantially in the 1820s following the successful collecting of more instruments and natural curiosities not only from Genevan scientists but also from foreign scientists. The former included Horace-Bénédict de Saussure and Marc-Auguste Pictet, whose instruments were acquired by the authorities in 1823. Many of these instruments and natural curiosities were later donated to the Museum of History of Science and are on display there.

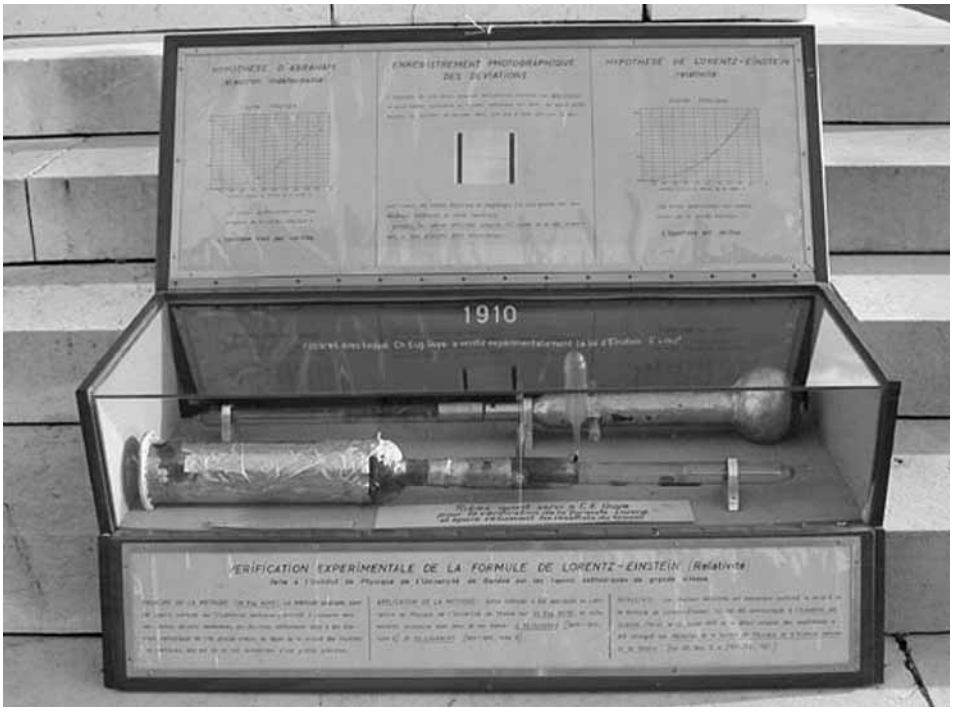

Fig. 9. The wooden casket containing the two cathode-ray tubes that Guye used in his experiments. The lower one was used in his second, decisive experiment. *Credit*: Museum of History of Science, Geneva.

in October 1933 he had left Germany and had immigrated to the United States.) On the well-known official photograph of the participants at the fifth Solvay Congress in 1927, Guye is sitting two places to Einstein's left.

Physics in Geneva after Guye

In 1930 a regular chair of theoretical physics was created at the University of Geneva whose first occupant was Arthur Schidlof (1877–1934), who probably is best remembered for proposing a pre-Bohr model of the atom.[20] After his death he was succeeded by Ernest C.G. Stueckelberg von Breitenbach zu Breitenstein und Melsbach (1905–1984),* who contributed decisively to research in modern theoretical physics at the University of Geneva and became one of the most illustrious Swiss physicists of the 20th century. He was an eccentric character, and although he was beset by a recurrent mental disorder, he made pioneering discoveries in nuclear and quantum-field theory beginning in the 1930s and continuing into the 1950s, such as those of the causal prop-

* Stueckelberg's mother had an aristocratic German ancestry of which he remained very proud throughout his life.

Fig. 10. The University building, erected in 1871. The left wing houses the central Library. Photograph by the author.

agator and of the renormalization group. His outstanding achievements remain to be properly assessed. He is buried in the *Cimetière de Plainpalais* where, as noted above, many other Genevan celebrities rest; his resolutely abstract monument must be seen to be appreciated.

In 1953 the physics laboratories moved from their location in the central university building in the *Parc des Bastions* into a new edifice, the Institute of Physics (*École de Physique*) at *24 Quai Ernest-Ansermet* on the north bank of the *Arve River* (figure 11).* This was the site of the Swiss National Exhibition of 1896, which accounts for the names of some of the neighboring streets, such as the *Rue du village suisse*, where an attraction that staged and glorified the mythical values of the alpine and rural Swiss way of life was located.

The Institute of Physics houses three departments, each of which bears traces of the physicist who founded and shaped it. The actual structure of the Institute owes much to Josef Maria Jauch (1914–1974), who returned to his home country in 1960 after a

* See its website <www.unige.ch/sciences/physique>, especially the information concerning the 50th anniversary of CERN.

Fig. 11. The Institute of Physics (*École de Physique*) of the University of Geneva at *24 Quai Ernest-Ansermet. Credit*: The Institute of Physics, Geneva.

successful career in the United States.* Jauch modernized the Institute and hired many young researchers to give new impetus to an institution which, during the last years of Jauch's predecessor, Richard Extermann (1911–2002), was losing touch with the most recent research. Jauch took special care to promote the Department of Theoretical Physics, his own field of research. He made it famous for studies on the foundations of quantum theory: Following the approach of John von Neumann (1903–1957) and George D. Birkhoff (1884–1944), Jauch and his student Constantin Piron (b. 1932) developed what is known today as the Geneva School of the axiomatization of quantum theory. Similarly, the Department of Solid State Physics underwent decisive development under the directorship of Martin Peter (1928–2002); it specializes today in superconductivity and more generally in the study of new electronic materials, a field in which it is the leading Swiss laboratory.** The Department of Nuclear and Corpuscular Physics has participated actively in CERN's LEP (Large Electron-Positron) experiments and is now getting ready for the ATLAS experiment; it also conducts research on astroparticle physics under the leadership of Professor Maurice Bourquin (b. 1941).*** A fourth Department of Applied Physics under the directorship of Pro-

* Jauch received his Ph.D. degree at the University of Minnesota in 1939 and subsequently was Instructor and Assistant Professor at Princeton University (1942–1945), a research physicist at Bell Telephone Laboratories (1945–1946), and Associate and Full Professor at the University of Iowa (1946–1959).

** Geneva houses the MANEP (MAterials with Novel Electronic Properties), one of the National Centers of Competence in Research; see its website <www.manep.ch>. These centers correspond to the Swiss national research priorities, which are decided at the federal level.

*** Professor Bourquin served recently as Rector of the University. In general, physicists are represented disproportionally high in the list of Rectors of the University.

Fig. 12. The interior of the annex of the Institute of Physics (*École de Physique*) showing CERN physicists at work on the magnets for CERN's Proton Synchrotron. *Credit*: The Institute of Physics, Geneva.

fessor Nicolas Gisin (b. 1952) is located nearby in another edifice and is one of the world leaders in the experimental and theoretical study of quantum entanglement and related phenomena. The Department of Astronomy and the Laboratory of Astrophysics, as noted above, are located in the Geneva Observatory in Sauverny.

CERN*

The European Council for Nuclear Research (*Conseil Européen pour la Recherche Nucléaire*, CERN) was formally established in 1952 and was renamed as the European Organization for Nuclear Research (*Organization Européen pour la Recherche Nucléaire*) in 1954, but retained its earlier acronym, CERN. Meanwhile, in 1953, following long and complex international negotiations, Geneva was selected as its site over Copenhagen and other contenders, primarily because of Switzerland's long history of neutrality and of Geneva's long tradition of hosting international organizations, not to mention its appealing natural surroundings and its proximity to various pleasant holiday resorts.[21]

The new Institute of Physics of the University of Geneva, as noted above, opened in 1953; it housed CERN's first Proton Synchrotron group, whose scientific and administrative teams began to arrive that October. Richard Extermann, then Director of the Institute of Physics, had offered to house the scientific team – but on the day of its

* See its website <http://public.web.cern.ch/public/welcome.html>.

Fig. 13. The first days during the construction of CERN. *Credit*: CERN, Geneva.

arrival he unexpectedly refused to admit it unless an official clearance could be obtained from high Genevan officials, probably because he was worried that the physicists in his institute might become marginalized in their own facilities. As it turned out, this problem was resolved quickly, and the group in charge of building the magnets for the Proton Synchrotron soon occupied an annex to the main building (figure 12), which can still be seen today. More space was made available for CERN's Director General and his administrative staff in the *Château de Cointrin*, a mansion close to the Geneva airport, and in some airport hangars. In May 1954 construction began on CERN's permanent building in the countryside near Meyrin (figure 13), a village close to Geneva on the French border. By the end of 1954, CERN's facilities covered around 2,500 square meters and employed more than one-hundred people. Today, CERN spreads out across the Swiss-French border, with its LEP ring, 27 kilometers in circumference, extending to the neighboring Jura mountains.* It employs 3,000 people from many countries in the world, including Japan, Russia, and the United States.

The University of Geneva today has about 15,000 students from all over Switzerland,** including many from the Cantons of Wallis and Ticino (which do not have their

* The LEP experiments were terminated in November 2000 to enable the construction of CERN's next accelerator, the LHC (Large Hadron Collider), which will be installed inside the same tunnel and is expected to produce its first test collisions at the end of 2007; see its website <lhc.web.cern.ch/lhc/>.

** See its website <www.unige.ch/en/>.

own universities). In common with universities in all Western European countries, the University of Geneva is nowadays facing financial and institutional problems. There is also some competition among its departments. Physics, in particular, is no longer seen as the dominant science as it was in the 1950s and 1960s: The number of physics students is declining, as the public today is more fascinated by advances in genetics than in fundamental physics, or even in astrophysics and cosmology. Owing to the peculiarities of the Swiss political system, much of which is based upon direct democratic participation, issues involving science policy are often presented to the public for a vote. Thus, as in many other Swiss cities, scientists in Geneva have learned that they must communicate with the public, defending their research and financial support, and trying to attract more students. Science in Geneva, more than ever before, is part of the reality of the city.

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