Science in a free sphere

"We Swiss feel that it is something of a mission to support the representatives of other countries to the best of our ability in our joint work," declared Federal Councillor Albert Meyer in Interlaken on July 3, 1931. Representatives from Switzerland and abroad were in the audience to celebrate the opening of the international research station on the Jungfraujoch. The opening was a great "work for the benefit of the world", Meyer proclaimed. Switzerland offered an ideal place where "the representatives of the other states will get to know each other [and] also respect and love each other". The Alpine state, which has had a liberal democratic tradition for centuries, exercises this mediating position not only politically, but also scientifically, he said. On the Jungfraujoch, the long Swiss tradition would now come together with the unifying power of science in a unique way: Firstly, the Alps were the "birthplace of Swiss freedom" according to the "axiom that freedom reigns in the mountains". Secondly, freedom was also a basic condition for science, because the spirit of science can only develop in a "free atmosphere" and thanks to "scientific fraternity". The invited guests were able to experience this free atmosphere for themselves, as an overnight stay on the Jungfraujoch was planned after the ceremony in Interlaken. The following evening was very exuberant. The reason for this was not only the influence of the altitude, which unleashed the spirit, but also the excessive consumption of white wine, which was advertised to the guests as "glacier milk", lightened the mood.

Not only was an unusual laboratory opened at alpine altitude, but also a hostel for international researchers: It was to be a "scientific hotel" where researchers could also meet as mountain dwellers. Interested parties could apply for accommodation and laboratory space depending on availability and conduct their own research. For this reason, no research question was specified and the premises were not designed for a predefined purpose. Only the Alps, with their enigmatic climatic conditions, provided the framework for the scientific work. The altitude acted as a natural laboratory environment, influencing experimental parameters such as air pressure or high-altitude radiation. The only thing that united all the researchers was the special location. The French neurologist Louis Lapicque expressed this in his own contribution to the opening as follows: "Le veritable terrain de la fraternité scientifique, c'est le laboratoire."

As Federal Councillor Meyer indicated in his speech, the Jungfraujoch not only facilitated cooperation among international researchers beyond science. Rather, various other interests were linked to the research station: people from politics, science, tourism and society at large ascribed a different impact to the research station depending on their perspective. In addition, the structure of the foundation is indeed special compared to other international scientific associations. Today, the Research Station Foundation is the oldest scientific foundation still in existence that is made up of an international committee and sees itself as an international organization. This form was not planned from the outset, but had to be worked out as a compromise after much effort. The following history of the High Alpine Research Station serves as a kind of prism to illustrate the spectrum of the framework conditions of Swiss and international science policy in times of upheaval. The focus is on the period from 1922, when the Swiss Society for Natural Sciences (SNS) established a Jungfraujoch Commission, to 1952, when the President of the Foundation and Station Director Alexander von Muralt formally announced the establishment of the Swiss National Science Foundation (SNSF).

Seen from the present, the special nature of the Jungfraujoch research station is made up of all these facets: The high alpine surroundings served the Federal Council as an imaginary elevation of the place, the special environmental conditions allowed researchers to study various phenomena in a natural laboratory environment, the scientific buildings allowed the station to be promoted for marketing purposes by the Jungfrau Railway, and the international foundation could be used in the media as a symbol of a neutral and peacemaking Switzerland in the middle of Europe, one that was particularly pronounced in the interwar period and almost even more so in the post-war period.

Lapicque made this point in the commemorative publication for the opening of the station in 1931: "Twelve years after the terrible war that devastated the world, we are still a long way from repairing the disasters it left behind. [...] I hope that this laboratory, this scientific beacon between France and Germany, will be a sign of reconciliation that will be acclaimed by the whole of Europe."

*Longing for the heights*

In his inaugural speech in 1931, Federal Councillor Meyer referred not only to the "free atmosphere and clear air" on the Jungfraujoch, but also to the "draw of the heights" that lay deep within the human soul: "Mankind has always believed that the best comes to it from above." The mountains, he said, had always exercised a special attraction. In fact, a special significance was ascribed to the Alps early on. The inhabitants of Alpine regions, for example, were regarded as an extraordinary breed of people. In the 18th century, the Alpine region was still "a place of original humanity, because it was guided by reason and nature". It was not least the terrible and beautiful superiority of nature that produced what were thought to be true human beings in the Age of Enlightenment. Before the development of the mountain peaks for tourism, travellers to the Alps were mainly limited to marvelling at the sublimity and liberating supremacy of nature, which could lead to almost religious experiences of nature. In the 19th century, the Alps were romanticized as a tourist attraction and attracted an international audience, initially individual adventurers and wealthy travellers, later the wider population.

Mount Jungfrau played a special role in connection with the rise of Alpine tourism. A short travelogue from the middle of the 19th century bears witness to this. When a German travel group accompanied by the American pastor George B. Cheever hiked from Lauterbrunnen via Wengen to Grindelwald on their journey through Switzerland, the group was met by a man at the top of the pass. Next to this man was a small cannon and an arrangement of strawberries, cake, cream and other delicacies. On asking, Cheever was told that the man was offering food and another special attraction for a fee: cake and strawberries could be bought for three cents, a single cannon shot for half that price. The cannon shot was used to trigger a shock at the request of the travellers, causing small avalanches on the Jungfrau massif. In this way, no one had to move on "without missing this greatest of alpine wonders", Cheever noted. Artificial avalanches, which according to Cheever could be shot down like pigeons in flight, were only surpassed for the American guest by the huge natural avalanches that raced down the flanks of the Jungfrau. In his enthusiasm, Cheever said: "I think this is without exception the greatest sight anyone has ever seen. Not even Niagara Falls has impressed me with such captivating grandeur." The rumble reminded him of distant artillery shots, the trampling of an army of elephants or an entire cavalry, the thundering of 10,000 bison on the prairie, stormy surf on the ocean, the trumpets of Sinai or even the "voice of the eternal".

The American guest was amazed at many things, but above all at the unleashed forces of nature on the Jungfrau. In view of his exuberant description of the Alpine dangers, it is not surprising that three decades later, when the railroad age had long since dawned in Switzerland, a railroad to the Jungfrau was also considered as a joke: A cartoon appeared in the *Neue Zürcher Zeitung* showing a train to the summit of the Jungfrau. What other mountain would have underlined the joke better than this terribly beautiful avalanche mountain? However, the age of imperialism and colonialism did not stop at the Jungfrau. A combination of the imperial urge to conquer and, according to technology historian David Gugerli, a "religiously motivated primal urge of mankind to reach the heights" as well as the great civilizational achievement of technical disenchantment formed the background for spectacular railroad projects in Switzerland. This was the beginning of widespread Alpine tourism and the desire for Alpine heights, as it was now possible for ordinary people to visit uncharted heights.

In addition to all the technical innovations, emotional work was also required to reconcile the appropriation of the Alpine region with its simultaneous elevation. Many of the large-scale rail projects that led to Swiss mountain peaks were exposed to harsh headwinds. Conservationists and nature conservationists were suspicious of what was happening, communities were divided over the touristic significance of the projects, and even large associations such as the Swiss Alpine Club (SAC) were not entirely positive about the conquest of the mountains for tourism. The railroad projects were therefore always characterized by a mixture of technical megalomania and a shudder at their own audacity. In the end, however, the urge to conquer dominated the country with colonialism without colonies.

*Era of spectacular rail projects*

A few decades after Cheever's visit to the Jungfrau Massif, the *Neue Zürcher Zeitung* reported sceptically in 1867 about a new cog railroad on Mount Washington in New Hampshire, USA. Its construction had begun the previous year and took the railroad to over 1,900 meters above sea level. The American cog railroad was of interest not least because a similar project for Mount Rigi was being worked on in Switzerland at the same time. The technology in the USA was not very efficient and only fulfilled "the purpose that a railroad or a balloon lifting system would have, as had been proposed for Mount Rigi", the commentator said. Despite all the scepticism, the American railroad provided an argument for the feasibility of a railroad to Mount Rigi. Doubts and reservations had been expressed, mainly out of fear of accidents; after all, there was hardly any experience with railroads on steep tracks. In addition to reports on the tourist success of the Mount Washington Railway, one technical detail was of particular interest: the rack developed by Swiss engineer Niklaus Riggenbach, head of the machine shop in Olten. This was used on Mount Washington and was also to be used for the Vitznau–Rigi Railway project. The Swiss Federal Council made an appreciative reference to the American railroad and the functioning Swiss-made system in its message on the concession application for the Rigi Railway of 1869.

In addition to the technical details, the prospect that "tourism is a not insignificant factor in the Swiss economy, and that the projected railroad, as a unicum in Europe, is undoubtedly capable of promoting it" was also attractive, according to the Federal Council on the concession of the Rigi Railway in 1869. It continued: "[...] it must be of the greatest interest for Switzerland, which still has so many tasks to solve in its mountainous regions with regard to the construction of railroad connections, to see attempts being made to solve the manifold difficulties in this area." Two years later, in 1871, the Rigi Railway was opened at over 1,600 meters above sea level. In the reports on the first trip to Rigi Staffel, in addition to the praise for the magnificent view, the safety of the railroad was the main topic of discussion. One expert present, the civil engineer and head of the Swiss Federal Institute of Technology (ETH) Carl Culmann, emphasized the scientific importance of the Rigi Railway amidst numerous toasts and said that he had just witnessed a great feat of engineering. Despite all the technical audacity, it was important to find a tone for the sublimity of the mountain world. The iron grip of the railroad age was not yet fully accepted, but the high elevationhad its own effect. The report on the first Rigi trip, for example, stated that "exaltation and reflection" about the experience and the Alpine air had made all political differences disappear and the travellers had found harmonious unity. The almost religious atmosphere at high altitude brought to light the emotional component of the mountain world, which was to be a recurring topos.

The Rigi Railway ushered in the age of mountain railway projects. In addition to the Vitznau– Rigibahn (1871), the Arth–Rigibahn was built in the canton of Schwyz (1875), followed ten years later by the Brünigbahn (1888), then the Pilatusbahn (1889), the Generosobahn (1890), the Brienz–Rothornbahn (1892), the Schynige–Plattebahn and Wengernalpbahn (1893) and the Gornergratbahn (1898). The railroads outperformed each other in terms of technical parameters. The Pilatus Railway, for example, "took first place among the Swiss mountain railroads as the boldest and most interesting [...]", wrote the *Neue Zürcher Zeitung*. Soon plans for railroads to the Matterhorn or the famous trio in the Bernese Oberland – the Eiger, Mönch and Jungfrau – also came to public attention. While most of the railroad projects got stuck in the planning stage, it was the Jungfrau whose summit turned the heads of several men and prompted them to apply for a concession.

*Plans for the Virgin and the significant Article 8*

In 1889, two interested engineers submitted a concession application to the federal government for the construction of a railroad to the summit of the Jungfrau: Maurice Koechlin (or in German: Moritz Köchlin) on October 16 and Alexander Trautweiler on October 22. In his application for a concession, Koechlin referred to the financial success of the Rigi and Pilatus railroads. He believed that a Jungfrau Railway would be even more successful than its two predecessors. He also argued that not only the mountain railroads, but also all other Bernese railroads would benefit: The accessible summit of the Jungfrau would effectively become the Eiffel Tower of the Bernese Oberland and would then attract numerous travellers. The summit would also offer space for a small meteorological and astronomical observatory. As early as 1889, the *Schweizerische Bauzeitung* reported that the highest station at the summit of the Jungfrau was also to house "a station for scientific, namely meteorological and astronomical studies". When the Federal Council discussed the concession application, it was positively noted that "a small meteorological and astronomical observatory [could] be built, which would serve for a variety of observations of high scientific value". Koechlin was awarded the concession in the spring of 1891, officially because he had submitted his application earlier than Trautweiler. Unofficially, Koechlin's collaboration in Gustave Eiffel's prominent engineering office may have been convincing, as was Koechlin's central contribution to the construction of the Eiffel Tower. Trautweiler's application for a concession was not considered.

Apart from liking the idea of using the railroad for scientific purposes, concerns were raised at a meeting of the Council of States on June 26, 1890. As with the Rigi Railway twenty years earlier, safety issues gave rise to discussion: Was rapid transportation over several thousand meters up into the air hazardous to health or not? It was agreed that the concession should only be granted once "an expert opinion on the question of whether and under what conditions both the construction and operation of a railroad up the Jungfrau would be possible without endangering human life in exceptional circumstances" was available. The decision-makers were particularly unsettled by altitude sickness.

*Altitude sickness as a mysterious phenomenon*

Symptoms of so-called altitude sickness or mountain sickness have been described since ancient times. People would feel a diffuse malaise that could express itself in a wide variety of symptoms. However, when scientists wanted to carry out experimental studies in the 18th century to actually observe altitude sickness in nature, the difficult environmental conditions at high altitudes thwarted their plans: it was almost impossible to differentiate between the various factors of fatigue, cold and reduced barometric pressure. One of the best-known accounts of altitude sickness in modern times is probably the travelogue by Alexander von Humboldt. When he climbed the Chimborazo in the Andes at an altitude of more than 6,200 meters, Humboldt was gripped by dizziness, clouding of consciousness, nausea and other symptoms. Like many others, Humboldt tried to discover the cause of these phenomena.

Altitude sickness was only systematically researched in the second half of the 19th century. Physiologists such as Claude Bernard, Denis Jourdanet, Paul Bert, Paul Regnard and Hugo Kronecker tried to fathom the mechanisms. In Italy, the physiologist Angelo Mosso studied altitude sickness. He founded the research station on Monte Rosa for this purpose, where he carried out climatic and respiratory physiology experiments. The results were published in 1894 in the book "Fisiologia dell'uomo sulle Alpi". The Bernese physiologist Hugo Kronecker also worked on altitude sickness, primarily inspired by the railroad project up the Jungfrau, and published the standard work "Die Höhenkrankheit" in 1903. The British physiologist Joseph Barcroft and the US physiologists Scott Haldane and Yandell Henderson also investigated the body's reactions at high altitude in the early 20th century. All of these researchers were convinced that experiments on altitude sickness could only be carried out in the laboratory to a limited extent. The rocky laboratory of the mountains was more suitable. In the second half of the 19th century, these various projects laid the foundations for the understanding of altitude sickness that is still valid today. According to this, altitude sickness is an individual and sometimes even fatal reaction of the body to the low air pressure and lack of oxygen at high altitude.

The concerns regarding altitude sickness were not plucked out of thin air. They resulted in Article 8 of the concession, in which proof of health safety was required. This was a novelty and had not yet been included in the concession applications for previous mountain railroads in Switzerland: not for the Rigi Railway, nor for the Pilatus Railway, the Schynige Platte Railway, or the Brienz-Rothorn Railway. A certificate of health safety had not been required for the large international projects either. This meant that it had to be proven before construction that the use of the railroad could not trigger harmful reactions – for instance as a result of altitude sickness. For example, when the Manitou and Pike's Peak Railway in Colorado, USA, took its passengers to a literally breathtaking 4,300 meters in 1891, there were only terrain and machine tests beforehand. The Lima–La Oroya line of the Ferrocarril Central Andino in Peru exceeded an altitude of 4,780 meters from 1893, as did the Ferrocarril del Sur, which reached an altitude of almost 4,500 meters. As in Europe, physiological side effects were observed during construction and later operation, but without consequences for the awarding of concessions for the individual lines; altitude sickness, known as *soroche,* wasconsidered an unavoidable evil when travelling in these regions, along with other dangers. In Switzerland, however, Article 8 influenced all subsequent concessions for railroad projects. Proof of safety was now standard above a certain height. This applied directly to the ultimately unsuccessful projects on the Matterhorn and the Eiger, which, among other factors, were hindered by the cost-intensive proof of safety.

One reason for the particular caution in the case of the Jungfrau was that the conditions in Central Europe were different from those in South and North America. The Peruvian tracks were adhesion tracks, which, unlike cogwheel tracks, are based on friction. These railroads must not be too steep and must not freeze over in winter, for example. Accordingly, such railroads need a lot of time to climb the required height, which prevents symptoms and effects of altitude sickness. In contrast, the cogwheel railroads, which were better suited to the climatic conditions of the Alps, meant that a greater difference in altitude was covered in a shorter time. In the case of the Jungfrau Railway, an adhesion railroad was not an option due to the low snow line in Europe, so the comparatively short transportation time became a question mark.

In the Jungfrau project, one detail complicated the situation. In addition to the steep track layout, a lift for the last section was intended to shorten the travel time: the planned cableway ended at an altitude of 4,093 meters, from where a lift ascended the remaining almost seventy meters to the summit. These "unusual conditions" in the current and future Jungfrau projects made it desirable to review this situation at the concession award stage.

The technical planning, on the other hand, did not raise any concerns at the Jungfrau Railway. However, the medical concerns required extensive investigations. On September 18, 1890, an initial theoretical medical report was obtained for Koechlin's project from Eduard Gerlich, Professor of Engineering at ETH Zurich, and Hugo Kronecker, Professor of Physiology at the University of Bern. Kronecker came to the conclusion that it was "not advisable from the point of view of health science [...] to grant permission to build a Jungfrau Railway before the concessionaire had proven the safety of such transportation". Kronecker's argument that a comparable ascent speed had only ever been achieved with balloons was particularly convincing. There were no major studies on the adaptability of human bodies in the face of such stresses. Kronecker suggested conducting a series of tests with different people who would be carried to an altitude comparable to the Jungfrau summit. He wanted to imitate passive transportation. However, this was too expensive for Koechlin's planning committee. Moreover, some of those involved thought that talk of altitude sickness was just hot air. They fundamentally questioned its reality.

In order to comply with Article 8, Koechlin obtained a further expert opinion from Kronecker. For cost reasons, Kronecker was commissioned to carry out experiments with a "pneumatic cabinet". This was intended to save on transport experiments. Such experiments had been known for some time, but Kronecker doubted that the results from the laboratory could be transferred to real-life conditions. He even warned: "If alarming symptoms of mountain sickness were to appear in the pneumatic chamber, the question would be decided in a manner unfavorable to the project; if no changes in the main life functions were noticeable, experimental conditions would have to be sought which corresponded more to the conditions on snow mountains." He therefore feared that a negative result with the pressure chambers would cause the Jungfrau project to fail, but at the same time he did not consider positive results to be useful.

Nevertheless, Kronecker initially carried out the required experiments on animals. And in the summer of 1891, he was able to use the pneumatic chamber for two weeks in the Schöneck spa hotel on Lake Lucerne for his experiments on 15 people of different ages. It turned out that symptoms of altitude sickness were more noticeable during activities at reduced air pressure – Kronecker had his test subjects do climbing exercises in the chamber – but that discomfort also occurred without any significant movement. This confirmed what Kronecker had expected: altitude sickness could also occur during passive transportation to altitude. All the experimental set-ups pointed to the illness-causing effect of a drop in air pressure. As a consequence of the tests, the existence of the aforementioned Article 8 in the concession was confirmed, which made all higher sections of the route up to the Jungfrau summit subject to an ongoing authorization requirement. In addition, Koechlin had taken over Eiffel's office in 1893 and was therefore working at full capacity.

*Medical therapy: Air conditions in the mountains*

Bodies react in very different ways to different climatic conditions, as has already been explained using the example of altitude sickness. In addition to the interest in the unhealthy climate at high altitudes, this realization also stimulated considerations with regard to the therapeutic effect of these reactions. Resourceful doctors such as Karl Turban believed that the high altitude climate was beneficial for tuberculosis because it stimulated the organism. Turban therefore founded the Turban private sanatorium in Davos, which gave the town a tourist boom in the following years and was immortalized in Thomas Mann's novel "The Magic Mountain". The idea behind this was that a change in climate could trigger the body's self-healing powers in the form of simple regulatory mechanisms. For the wealthy clientele, a stay at a spa in high-altitude regions was therefore an obvious choice. On the one hand, this led to the well-known upswing in high-altitude health resorts, where the natural air conditions promised a therapeutic effect on various lung diseases. At the same time, however, equipment was developed to replace a trip to the mountains. In medicine, for example, pressure chambers were used as a form of therapy in the second half of the 19th century because the effects of positive and negative pressure (in addition to other climatic conditions) were considered beneficial for certain lung diseases and other ailments. Well-known spas therefore offered pneumatic cabinets in addition to other fashionable therapies such as water and bathing cures, air cures and recumbent cures. One example in Switzerland was the Schöneck health resort on Lake Lucerne, which offered the entire therapeutic program for lung patients, including pneumatic equipment from the 1880s onwards. Despite the technical alternative in the lowlands, alpine tuberculosis sanatoriums continued to exist well into the 20th century, and treatment there was actively promoted by the doctors responsible.

In addition to his own experiments, Kronecker was also interested in reports on international mountain railway projects and how they dealt with altitude sickness. In 1892, for example, he came across the Peruvian high mountain railroad in the *newspaper of the Association of German Railway Administrations* and asked Emil Welti, the head of the Swiss Railway Department, about this project. Through the consulate in Lima, Welti obtained a report from Wertheim, a Swiss engineer employed there, who stated: "Every day people travel (on the railroad) from Callao (2 meters above sea level) to Yauli (4,090 meters) through the high altitude tunnel of 4,775 meters, who have never been to higher altitudes. Most of them probably suffer from soroche, but there is never any talk of accidents. Mountain sickness, like seasickness, is a malady that affects most people, but there are few who do not get used to it." Ernest Malinoswki, chief engineer of the Peruvian railroad, recommended providing passengers with compressed oxygen or hermetically sealing the carriages and keeping them pressurized. Apart from this, the high altitude phenomena did not trigger any further reactions in Peru.

Obviously, the issue of altitude sickness was not very problematic for the engineers involved in North and South America. Even on the Jungfrau Project, not everyone took the danger equally seriously. One of the engineers involved, for example, said that "so-called mountain sickness [...] was always due to excessive consumption of alcohol, dietary errors or overexertion due to the march". Something similar happens – he argued – when you overexert yourself when cycling, rowing or running, because then "exactly the same symptoms of so-called mountain sickness" occur "even if there is no mountain around for miles". However, physicians and physiologists were unwavering in their determination to prove safety under Article 8, especially as the death of a young doctor from Neuchâtel caused a stir in the Swiss media in 1891. He had fallen ill during a stay at the Vallot hut on Mont Blanc at 4,360 meters above sea level and died shortly afterwards. Despite all doubts about the dangers of altitude sickness, precautionary measures had to be taken.

*High alpine stations around the world*

On most alpine expeditions in the 19th century, researchers used tents, which limited the instruments they could bring with them and the experimental possibilities. Apart from the huts for alpinists, there were only high observatories in America, for example in California at over 1,300 meters or in Peru at over 3,000 meters. In Italy, the Capanna Regina Margherita at an altitude of over 4,500 meters was added in 1893. Although the hut was well developed from the Italian side, accessibility on foot limited the Capanna's possibilities. At the Physiology Congress in Turin in 1901, it was decided that the physiologist Angelo Mosso should take advantage of this opportunity and also build a proper scientific station.

There were also similar projects in France. After an expedition to Mont Blanc, the private scholar Joseph Vallot built a simple hut below the summit, which provided sleeping accommodation and a sheltered space for experiments. In September 1893, Jules Janssen, director of the astrophysical institute in Meudon, climbed to the summit of Mont Blanc with a group to carry out astronomical observations. Janssen then had a proper observatory built on Mont Blanc, which existed for just over ten years. The Janssen expedition of 1893 caused a stir throughout Europe, partly because of Janssen's assertion that the French project was open to international guests. One commentator remarked: "It is a beautiful thought that there should be a little hut high above the various states of Europe and all that separates them, where their sons, as pure representatives of the whole human race, can join hands as brothers in the search for truth, and that this little hut should rise on the immaculate summit, which exchanges the first morning and last evening greeting with the sun, which certifies us all equally!"

In addition to scientific interests, imperialist fantasies often played a role in these expeditions, which, as in the case of the Janssen Observatory, were presented as European projects. This also applied to a country like Switzerland without its own colonies, where, like the vastness of the eternal ice of the Arctic or the exoticism of Indonesia, altitude also attracted the interest of Swiss naturalists because it combined science, national self-imagination and a spirit of adventure. By the end of the 19th century, these symbolic dimensions of Alpine heights had already taken shape: the Alpine region as a European–international and homosocial space of experience, but also as a natural laboratory, as a predestined vantage point for meteorological and astronomical observations and, of course, as an extreme test environment for physiological experiments.

*A second attempt for the Jungfrau Railway*

In the case of the first concession for a cable car up the Jungfrau in 1891, Koechlin's project failed due to proof of safety and the financial burden. Others already sensed the business opportunities. Among them were Emil Strub and Hans Studer, who submitted a concession application on February 12, 1892 for a parallel project to run a railroad from Kleine Scheidegg to the Eiger. Although this application was also assessed positively, it failed due to lack of money. In the case of other and older successful railroad projects, the money problem had always been solved by the fact that there were often entrepreneurs with connections and large financial resources in the background. Industrialists also often wanted to create a monument to themselves with the Protestant magic formula of money and spirit. Thanks to their connections, the wealthy entrepreneurs brought in the necessary financial resources in the form of public limited companies. Unlike penniless engineers, they were able to speculate that the tourist attraction they created would pay off. From a financial point of view, railroads in the 19th century were huge speculative projects that were often carried out on the shoulders of the local population and workers.

As for the Jungfrau Railway, it was the railroad entrepreneur and politician Adolf Guyer-Zeller who took over the Jungfrau Railway project from Koechlin in 1893 and was also to see it through to completion. Guyer-Zeller had inherited a huge fortune from his father with the Neuthal cotton mill in the canton of Zurich and had also made large profits with railroad shares. Thanks to this money, Guyer-Zeller became active as an entrepreneur and proved to have a good nose for the railroad business in particular. Guyer-Zeller even founded a financial business specifically for the Jungfrau Railway project: the Guyerzellerbank. Guyer-Zeller is said to have had a flash of inspiration during a hike above Mürren in 1893, which he ingeniously sketched in his diary. From Mürren, the Jungfrau is clearly visible on the other side of the valley – and Guyer-Zeller's visionary eye immediately recognized the optimal route for the railroad from Kleine Scheidegg, which had been opened up for tourism by the Wengernalp Railway that year. Without further ado, Guyer-Zeller submitted a concession application to the federal government in December 1893. This sketch from his diary has remained in the collective memory as a testimony to his Faustian deed, despite the fact that after the concession was granted, he also announced a design competition worth 30,000 francs, thus leaving the actual design of the railroad to the real experts.

Guyer-Zeller was excellently networked and knew how to skillfully position the project in the media. For example, Guyer-Zeller referred to the well-known balloonist Eduard Spelterini when submitting the concession application in December 1893. Spelterini, an acquaintance of Guyer-Zeller, confirmed that the "fear [of altitude sickness] was unfounded, as he had already climbed over 4,000 m in a balloon with people of various constitutions, without them experiencing any particular discomfort, a circumstance that can be explained by the fact that the people concerned are taken to those heights without making the heart work any harder than when the body is at rest". Guyer-Zeller also contacted Hugo Kronecker, who was already very familiar with the Jungfrau project, and requested a further expert opinion. This time, money was not the issue. This may also have been one of the reasons why the concession application submitted to the Railway Department on December 20, 1893 could not be presented to the Swiss parliament in the July session of 1894 as planned. Instead, the application was postponed to the December session without any information being provided about the reasons. Guyer-Zeller probably had a hand in this. He wanted Kronecker to repeat his pneumatic experiments of 1891 under real conditions. All the more so in light of the Mont Blanc incident and the death of the young doctor, which Guyer-Zeller had been told about personally by the Alpine pioneer Eduard Imhof, who was also present on the excursion. Kronecker was immediately ready for action, as he was convinced that field studies, especially in high-altitude physiology, produced different results than laboratory studies. In this regard, he said: "Mountain sickness should not be studied and avoided at the green table, but on the green Alps."

In the summer of 1894, Kronecker led an illustrious group of seven people on an excursion to the Breithorn near Zermatt: the group consisted of Kronecker and his wife, his assistant and later successor Leon Asher, a ten-year-old boy, a farmer from Zermatt aged over seventy and the professor of medicine Hermann Sahli and his wife. There were also two guides and 42 porters as well as other people. The aim was to get the test subjects to an altitude of over 4,000 meters without any effort on their part in order to simulate the train journey to the summit of the Jungfrau as realistically as possible. This was precisely where the uncertainty lay, because ascents to higher altitudes under their own steam with the corresponding ascent speed were well known. However, passive transportation in a cable car in combination with the higher ascent speed could not be estimated correctly. Kronecker finally carried out the measurements at an altitude of 3,750 meters. They confirmed the expectations: The blood circulation changed and symptoms of heart disease emerged clearly. However, the symptoms were only noticeable at over 3,000 meters when the person in question made strenuous movements, and the same was true to a greater extent up to 4,000 meters. Kronecker therefore advised Guyer-Zeller to "set up the train in such a way that passengers can enjoy the full view without having to climb in the slightest". He also recommended that a doctor be stationed somewhere along the route to assist passengers. "This would free the railroad administration from all responsibility and show that it is as concerned as possible with the well-being of the passengers entrusted to its care."

While Kronecker was carrying out his experiments, Guyer-Zeller was also active. He used the time between the July and December sessions of 1894, for example, by contacting the members of the parliamentary commission to prepare them for the upcoming vote on the concession application and to provide them with additional information material. He sent various members of parliament material on Kronecker's latest experiments. He also sent the decision-makers his concession application, which he had expanded to include a crucial point after the submission: he had arranged for the inclusion of Article 9a, which was to set a decisive course for the history of the Jungfraujoch research station.

After submitting the first application on December 20, 1893, Guyer-Zeller quickly submitted an amended application on February 13, 1894. The draft of the concession application subsequently prepared by the Federal Council on this basis differed from other railroad concession applications in a number of respects. Perhaps the most important addition was Article 9a, which was included "at the request of the concession petitioner" and was intended "to make the Jungfrau Railway useful to science by obliging the company, after partial or full completion of the line, to contribute a one-off sum of at least CHF 100,000 to the construction and installation of a permanent observatory for meteorological and other telluric-physical observation purposes at the Mönch or Jungfrau station, or possibly at both." 100,000 and an annual contribution of up to Fr. 6,000 towards the operating costs, on the understanding that the company would have to allow any further subsidizers to participate in the construction and operation of the observatory or observatories, but that it would have the right to make decisions. In short: with this article, Guyer-Zeller was obliged to build an observation station in addition to the Jungfrau Railway.

Later reports on the development of the Jungfrau Railway often explained that Article 9a was a condition of the Confederation and an involuntary burden for the Jungfrau Railway. This interpretation was obvious, because around thirty years later there was friction between the railroad and research when the station was being planned. However, the opposite was the case: the research station had been a personal concern of Adolf Guyer-Zeller and was the result of an independently formulated request. After the cantonal governments of Bern and Valais had welcomed the application, Guyer-Zeller and the representatives of the Confederation met in the old Federal Council building in Bern on May 11, 1894 to finalize the draft concession. Guyer-Zeller proposed Article 9a at this very meeting – "spontaneously", as was later reported. On May 19, 1894, Guyer-Zeller confirmed the proposal made at the last conference, and the wording from the letter of May 19 was incorporated into the concession virtually unchanged.

Soon nobody remembered exactly which demand had actually been decisive for the inclusion of Article 9a in the concession letter. The Department of the Interior, where the relevant documents were kept, later stated: "Neither the minutes of this conference nor the other files from our department reveal why Mr. Guyer proposed this Article 9a. The minutes of the negotiations of the Federal Councils from that time also contain no information on this." We must therefore speculate about the motives for the inclusion of Article 9a. It is possible that the presentation of the summit station as a place of science to Parliament and the public demonstrated a sensitivity to the problems and unresolved issues of altitude. The scheduled station doctor and the promise of future research guaranteed that the problem of altitude would be taken seriously. It was also in Guyer-Zeller's interest to provide proof of safety as soon as possible, as he feared that the continued existence of Article 8 ("proof of safety") would cause potential sponsors to doubt the feasibility of the project. Accordingly, Guyer-Zeller had tried to ensure that the corresponding Article 8 on proof of safety was completely removed from the draft concession by making targeted contact with members of parliament. The construction of a scientific station was intended to make further research into the mystery of mountain sickness possible and was, to a certain extent, an offer that this station would provide the best expertise in high-altitude physiology right on site. The Jungfrau Railway almost had to be built in order to establish a research station, which in turn could legitimize the operation of the Jungfrau Railway.

This interpretation is supported by the fact that Kronecker's physiologist Leon Asher retrospectively reported in 1932 on Kronecker's influence on the creation of Article 9a. Asher had worked as Kronecker's assistant from 1894 and was therefore familiar with his enthusiasm for the Jungfrau project. Kronecker had not only been consulted for the studies, he had also "at the time very eagerly pursued the plan for a high alpine research station". Asher also reported that he had heard discussions between Kronecker and the most renowned physiologists of the time – the American Henry Pickering Bowditch, the Frenchman Étienne- Jules Marey and the Italian Angelo Mosso – about such a project. He also submitted an application to the Federal Council: "For anyone who is personally familiar with contemporary history at the turn of the century, there is no doubt about Kronecker's close connection with the idea of a research station for biological purposes on the Jungfraujoch."

In 1932, when Walter Rudolf Hess, who later became station president, was researching the history of the research station for a conference of the Swiss Society of Natural Scientists (SNS), which included a visit to the Jungfraujoch, he asked the Department of the Interior about possible files in Thun: "In order to be on very solid ground in this regard, it would be very valuable to me if I could gain an insight into an expert opinion [...]". Hess was particularly interested in Kronecker's allegedly active role, especially as the eyewitness and colleague Asher had reported such a role. However, after studying the files sent to him in detail, Hess came to the conclusion: "In fact, however, I cannot find any word from Kronecker in the files made available to me that points in this direction. In the interests of the matter, I would therefore like to ask you once again whether there is any document that could authentically establish Kronecker's relationship to the plan for a high-alpine research station." The Department of the Interior replied that even thorough research in the Federal Archives into Kronecker's role with regard to the research station had not yielded any results. Although the question of Kronecker was not clarified, his assessment gave the Jungfrau project a special character and the Jungfraujoch in the scientific community for the first time through publications.

*Hugo Kronecker - a world-class physiologist*

One of the most active figures in internationalist-minded physiology at the end of the century was the German physiology professor Hugo Kronecker. Born in 1839 in Silesia into a wealthy merchant's family, Kronecker attended grammar school in Liegnitz. He then studied medicine in Berlin, Heidelberg and Pisa and obtained his doctorate in 1863 under the renowned physiologist Emil du Bois-Reymond in Berlin. He studied physiological regulation processes of the body, for example circulatory functions, which became a central subject of investigation in the general physiology of the late 19th century. Against this background, Kronecker was also interested in altitude sickness. In addition to further contacts with important German physiologists, including Carl Ludwig in Leipzig, he expanded his network in Europe and also in the USA. In 1884, he became Professor of Physiology at the University of Bern, a position he held until his death in 1914.

Kronecker worked on the institutionalization of the international scientific community. He was also a founding member of the International Physiological Congresses. The founding meeting in September 1888 even took place in his house in Bern. He also participated as a representative of the natural sciences in other international undertakings, such as a conference for the establishment of an international catalog of scientific literature in Bern in July 1896. He was also centrally involved in the establishment of the Marey Institute in Paris as well as in the planning of the international Col d'Olens Institute (Monte Rosa), which was initiated by Angelo Mosso. Kronecker was a close friend of both Marey and Mosso. In these activities, it helped enormously that the polyglot Kronecker was able to communicate fluently with most of the physiologists in their respective languages. However, Kronecker was not only present abroad in the establishment of research facilities, he was also committed to domestic research facilities. For this reason, he was one of the most influential scientific and political figures in Switzerland at the turn of the century. At the same time, hardly any other physiologist represented the classical period of German-speaking physiology better than Kronecker, as was written in an obituary in the journal Science. In fact, he was one of the last figures to have personally known many of the most important physiologists of the 19th century. He outlived Mosso and Bowditch by a few years and died in Bad Nauheim in 1914 on his way home from the German Physiological Congress.

Based on his research, Hess did not assume that Kronecker had actually taken steps to actively promote a research station. He therefore stated: "It is no longer possible to determine who was actually responsible for the intellectual authorship and especially for the formulation of this provision, and to what extent tactical motives may have played a role alongside purely scientific interests." It was clear, however, that in addition to Kronecker, various acquaintances of Guyer-Zeller had also expressed desires, for example the meteorologist Julius Maurer, Director of the Central Meteorological Institute of Switzerland. It was also clear that the idea of using the high altitude for scientific purposes met with an open ear in parliament. It must have seemed strategically advisable to Guyer-Zeller to copy Koechlin's successful first application, including the scientific use of the high alpine location. Guyer- Zeller had a bad reputation in the banking world and was therefore reliant on anything that supported his project. Furthermore, both Guyer-Zeller and parliament must have been aware that in Switzerland in particular, science was one of the areas, alongside engineering, where pioneering achievements could still win renown/fame in the late 19th century: A research station on the Jungfrau summit would have been hard to beat in terms of scientific prestige. The concession application was part of a broader international movement in its referenceto meteorological or astronomical research. It had a Europe-wide propagandistic appeal. Science had also proved to be an interesting foreign diplomatic platform through the founding of international societies and measurement networks. A prestige object such as the planned laboratory on the Jungfrau would therefore have suited Swiss science only too well.

*Meteorology and astronomy as international disciplines*

In the second half of the 19th century, numerous observatories and meteorological observation stations were set up in Germany and abroad. Among other things, the spread of telegraph networks played a role in this, bringing distant stations closer together. As disciplines of the sky, astronomy and meteorology had always been dependent on international exchange, but the acceleration of information flows further intensified this exchange. Added to this were national interests in measurements and data. Against this background, the Viennese meteorologist Julius Hann, initiator of the Austrian Sonnblick Observatory, called for the establishment of a network of high-altitude measuring stations at the Second International Congress of Meteorology in April 1879. Hann mentioned Switzerland in particular: the International Meteorological Assembly considered "the establishment of a summit observatory in Switzerland to be particularly desirable", especially as "Switzerland has already had the densest existing network of high-altitude stations for a number of years and has publicized and distributed the observations at these stations to meteorologists with the greatest liberality since 1863".

In 1880, the Swiss Central Meteorological Institute was founded in Switzerland, which coordinated the measurements described by Hann and readily complied with Hann's request with the support of the Swiss Society for Natural Research and other institutions. The director of the Swiss Meteorological Institute, Robert Billwiller, personally received Hann for an inspection of the Säntis station. Billwiller described how the Swiss public showed great interest in the construction of the Säntis station.

The International Glacier Commission, which was founded at the International Geological Congress in Zurich in 1894 and whose successors are still based in Switzerland today, also belongs to the field of institutionalizing international meteorology. Astronomical observations had gained equal attention, and parallel to meteorology an international astronomical network was formed, in which Switzerland was prominently represented by renowned researchers such as the director of the Geneva Observatory, Emile Plantamour, the first director of the Swiss Semper Observatory, Rudolf Wolf, and the topographer Heinrich Wild.

It is quite possible that Guyer-Zeller was also thinking about the protection of local heritage and nature, which were the second major obstacle alongside health concerns. Despite initial resistance, the conviction finally arose in "circles committed to nature conservation" that "the railway line, which was to be driven up to then and since then unique heights, would promote purposes whose importance no one can fail to recognize". In this respect, research into altitude sickness was also a convincing argument for the protection of local history and nature. In any case, the concession including Article 9a was granted without amending Article 8. Later, for the stages above the critical altitude, it was simply assumed that the required points had been met. For the December 1894 session, further expert opinions on the official route had apparently arrived too late, but on July 18, 1895, the Federal Council declared Article 8 to have been fulfilled for the first sections. The only decisive factor for the first sections was proof of sufficient financial resources, which had to be available. This was easy for Guyer-Zeller, so that construction of the lowest section of the project from Kleine Scheidegg station to the Eiger Glacier could begin in the summer of 1896. Finally, in 1898, the first section was officially opened. The Eigergletscher station served as a base for the workers during the rest of the construction period, and later also provided office space for the Jungfrau Railway management. The other sections of the Jungfrau Railway made less rapid progress because construction turned out to be more expensive than expected. The plans for a research station also receded into the distance because the actual initiator fell silent with the death of Guyer-Zeller in 1899.