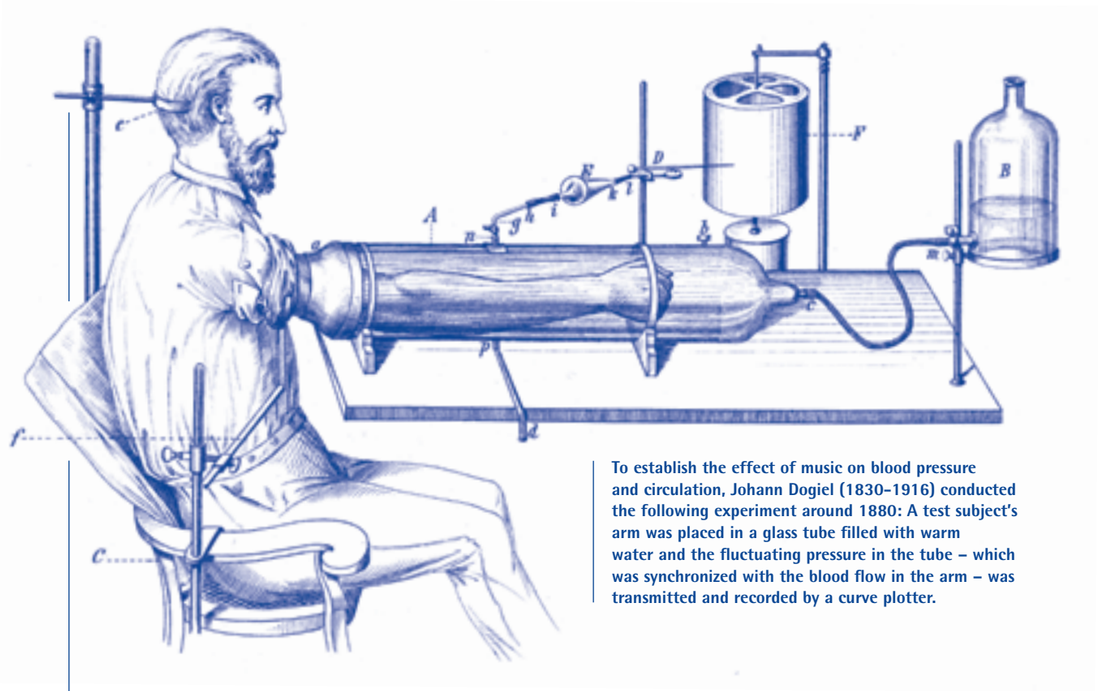


To establish the effect of music on blood pressure and circulation, Johann Dogiel (1830–1916) conducted the following experiment around 1880: A test subject's arm was placed in a glass tube filled with warm water and the fluctuating pressure in the tube – which was synchronized with the blood flow in the arm – was transmitted and recorded by a curve plotter.

PHOTOS: MPI FOR THE HISTORY OF SCIENCE/DEPARTMENT III

The Machinery of Life

Not just the world, but man, too, was surveyed exhaustively in the 19th century: physiologists investigated the machinery of the body, its electrical and mechanical mechanisms, the muscles and the nerves. There were lively discussions about what constituted the substance of the soul, whether there was a mysterious life force that distinguished a dead organism from a living one, and how life on Earth had come to be.

All of this eventually became too much for the confines of private scholars' rooms, even though astonishingly complex experiments long continued to be conducted in student lodgings and hotel rooms. Spacious, well-equipped laboratories were established in many of Europe's cities, where scientists could carry out series of tests with the latest measuring instruments under strictly controlled conditions. "The natural sciences underwent a dramatic transformation at that time. From the rather more romantic and qualitative research of nature emerged the modern methods of laboratory research as it is basically still practiced today: precision, repeatability, controlled conditions. Scientists attach enormous importance to all of these things," explains Henning Schmidgen, a science historian at the Max Planck Institute for the History of Science in Berlin.

Schmidgen and his fellow researcher Julia Kursell are working on a huge virtual archive on the origins of physiology, the "Virtual Laboratory: Essays and Resources on the Experimentalization of Life," or VL for short. The VL covers the period between 1830 and 1930, a scientific heyday in Germany, framed between the revival of natural science after Hegel's death and the start of Nazi rule. More than 30,000 documents, manuscripts, entire volumes of journals and books, as well as the experiments themselves and the instruments that were available, can be found here with just a few mouse clicks.

A visit to the VL can replace a complicated journey to the various collections on the history of science and through the museums of the world, saving travel costs and the valuable originals in equal measure. Furthermore, the VL has the world's most extensive collection of catalogues containing descriptions of measuring in-

In the mid-19th century, scientists were not squeamish when it came to exploring physiology: on live animals, they studied how the organs worked or how the nerves transmitted impulses – and even subjected human beings to electric pulses. Yet, even without such menacing methods, a great deal of fundamentally new knowledge was discovered. Researchers at the **Max Planck Institute for the History of Science** *are currently documenting the history of the origins of physiology in the Virtual Laboratory on the Experimentalization of Life.*

"The professor's coming" – driving up a test person's blood pressure: This document demonstrates the blood pressure curve and forms part of the bequest of physiologist Angelo Mosso (1846–1910) from Turin. Mosso studied under Carl Ludwig (1816–1895) in Leipzig and recorded a test subject's reaction to Ludwig entering the room in this measurement log.

French physiologist Guillaume-Benjamin Duchenne (1806–1875), also known as Duchenne de Boulogne, studied people's emotions, among other things. He used electrodes in an attempt to induce typical movements in the facial muscles. Some of his human guinea pigs suffered facial paralysis – making his photographically documented analyses all the more convincing.

struments from the period. "These catalogs, 190 in all, have been made available to us by private collectors. So rather than being lost, they are now accessible to scientists all over the world," says Schmidgen.

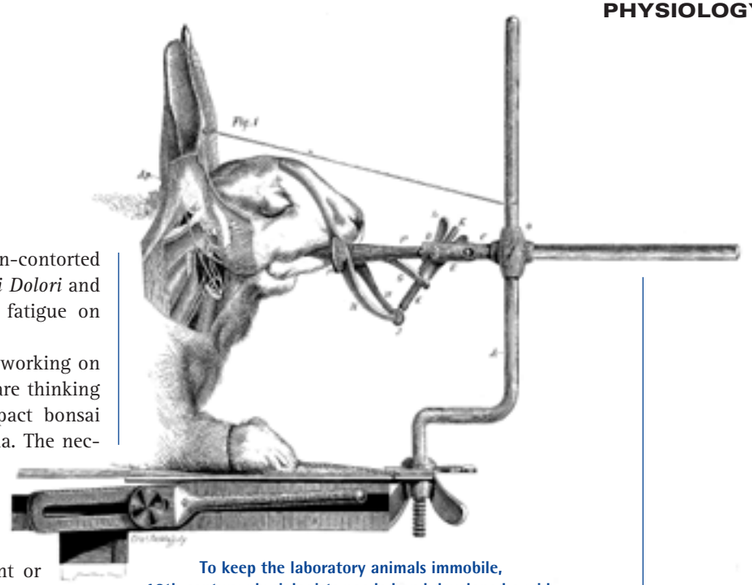
Schmidgen and Kursell are continuing what their fellow scientist Sven Dierig started a good 10 years ago: Back then, Dierig recognized the immense possibilities offered by the World Wide Web. Together with Jörg Kantel, who was head of IT at the Max Planck Institute for the History of Science and in charge of the technical side of things, he came up with the idea for a project to create a virtual laboratory, available on the Internet to any interested party, but particularly positioned as a common global platform for scientific historians. In the early days, the VL concentrated on the first major physiological institute, which Emil du Bois-Reymond had managed to establish in the heart of Berlin after more than 20 years of tough negotiations with Prussian bureaucrats. Soon, however, the time span and the region covered by the VL expanded. Today it contains documents from throughout Europe.

A modest idea becomes a major undertaking

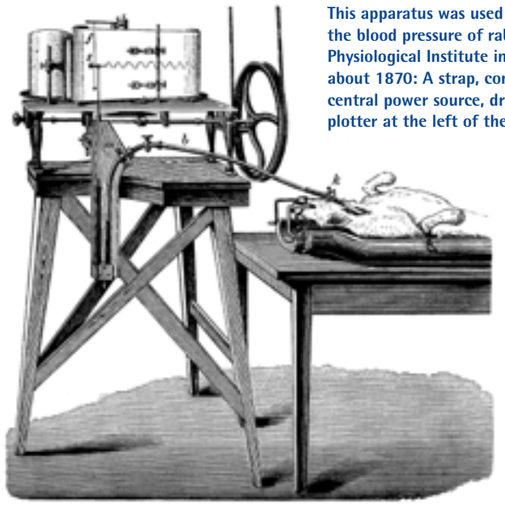
There is a chimera on the home page, half frog, half machine, with an austere "Enter" underneath, marking the way into the rest of the website. From there, the main navigation is reached, where the literature can be searched by keyword or author, manuscripts leafed through, a demonstration viewed of how the instruments worked, and frogs' legs made to twitch – all made possible by simple animations. The project was sponsored by the Volkswagen Foundation for the first five years; since then, the Max Planck Institute for the History of Science itself has undertaken to continue and develop the project. This one idea has now become a major undertaking, with about eight people working steadily on it.

A team of students handles the painstaking process of scanning and transcribing the valuable original documents; Dirk Wintergrün and Michael Behr keep the technology up to date. When necessary, team members and doctoral students working on the Experimentalization of Life project also take their digital equipment to wherever interesting documents are stored. For instance, one of the doctoral students, Philipp Felsch, traveled to Turin to scan each of the documents from the bequest of physiologist Angelo Mosso piece by piece, recalls Julia Kursell.

One of the most exciting finds is a blood pressure curve, on which Mosso himself explained the sudden rise with the note: "The professor's coming." The approaching steps of Mosso's then-supervisor, audible through the door, had obviously made the test subject nervous. Gruesome eye-catchers among the papers in



To keep the laboratory animals immobile, 19th century physiologists needed and developed a wide range of apparatuses – including this rabbit holder, designed by Johann Nepomuk Czermak (1828–1873).



This apparatus was used to measure the blood pressure of rabbits at the Physiological Institute in Leipzig in about 1870: A strap, connected to a central power source, drove the curve plotter at the left of the picture.

Mosso's bequest include photos of the pain-contorted faces of human guinea pigs in the *Album dei Dolori* and pictures taken during his investigation of fatigue on mountain hikes.

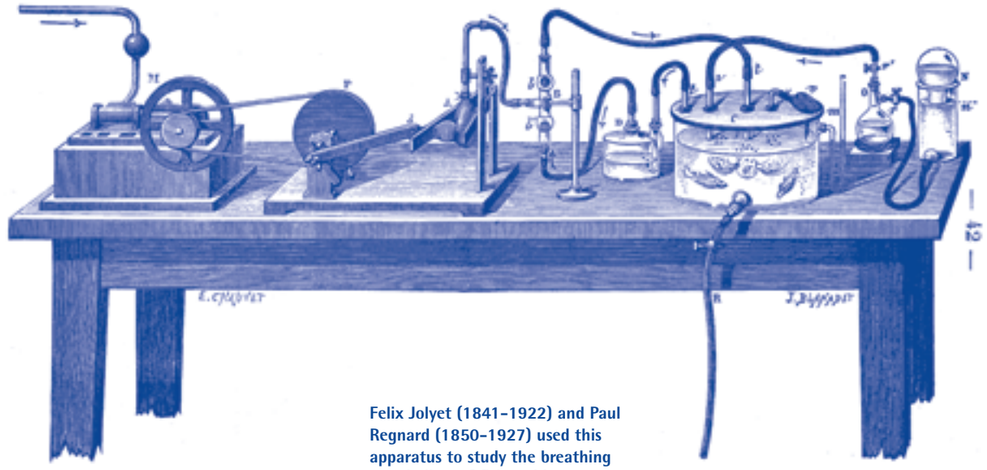
Henning Schmidgen and Julia Kursell are working on making the VL even bigger, although they are thinking more along the lines of an ornately compact bonsai rather than a rampant climber like Wikipedia. The necessary "gardening" – in addition to the actual scientific work, some of which they likewise do in the VL – entails considerable effort. "We receive a lot of offers, but not every kind of original manuscript, document or catalog is of interest to us; we are extremely selective," emphasizes Schmidgen.

Some of the works, studies and essays that students, scientists or even laypersons write with the help of the VL can be published there if they fit in with the subjects covered, contain new ideas and are persuasive. However, all contributions are subject to critical discussion; the works pass back and forth between Kursell, Schmidgen and the authors. In this sense, the VL is like a preliminary stage of an electronic journal, which Kursell and Schmidgen say is certainly one option for the future.

Novices might find it useful, having taken an initial stroll through the VL, to take a look at one of the comprehensive essays that have made it into the VL. In these essays, scientists examine various hypotheses, uncover connections between the events of the day and what was going on in the laboratories, and document their interpretations with numerous anecdotes and quotes gathered from the VL or elsewhere. The VL is, after all, a forum for experts. Beginners can easily get lost in the illegible handwritten notes, unable to see the forest for the trees, and even the twitching frogs' legs, bleeding rabbits and other spectacular experiments can get wearisome – the animations are sparing and merely demonstrate the principle. What is exciting, though, is what can be derived from the raw material. For this, however, mountains of literature must be digested, which requires quite some time and knowledge.

For example, cultural scientist Christof Windgätter describes in his essay entitled "... with mathematic precision" how high the expectations of the simple measurement of physical strength were in those days. Scientists carried, for instance, dynamometers with them on their expeditions around the world in order to compare the strength of foreign peoples with the muscle power of European mariners, a comparison that usually came out in favor of the trained sailors and was taken as proof of the fundamental superiority of European man. A person's moral condition, mental health, and even their criminal tendencies were also identified based on physical attributes.

Scientists suspected a close connection between psyche and body, meaning that deficits in mental capacity or social behavior would necessarily be reflected in deformed skulls or weak muscles. This popular thesis fascinated Friedrich Nietzsche – his übermensch was not only mentally fit but also physically – and the words and phrases he personally underlined in Charles Féré's work *Dégénérescence et criminalité* can be viewed in the VL.



Felix Jolyet (1841–1922) and Paul Regnard (1850–1927) used this apparatus to study the breathing metabolism of fish and invertebrate aquatic animals. On the left is the machine for artificial respiration by means of a mechanical pair of bellows, which was powered by a hydraulic motor connected to the lab's water supply.

Windgätter also presents the notes of Sigmund Freud, in which, as a medical intern, Freud painstakingly recorded the effect of cocaine, both on his mental constitution and on the strength of his arm muscles.

Even the subtlest of emotional stirrings follow natural laws

If living beings were machines, then physiology was an organic physics. The prevailing opinion of the day was that measuring physical parameters enabled scientists to determine people's frame of mind and character traits. Conversely, it was believed that certain stimuli must invoke certain expressions of mood: by applying an alternating current, it was possible to make a man whose face was paralyzed appear to smile, as demonstrated by Duchenne de Boulogne, a doctor and researcher at the Salpêtrière asylum in Paris.

"In the past, people thought that the human spirit was able to act independently of the laws of nature," wrote Francis Galton, a cousin of Charles Darwin, in his seminal work *The Hereditary Genius*. Now, he believed, it was possible to prove that even the subtlest of emotional stirrings, abilities, and even criminal tendencies were determined by nothing other than the laws of nature. Galton promoted the idea of eugenics, or human breeding that would produce increasingly superior humans in the course of controlled, accelerated evolution from generation to generation, as he cynically propagated back then.

"Even ideas that have recently been taken up again and discussed intensely, such as free will, are by no means new, and the viewpoints and arguments repeat themselves occasionally," says Schmidgen. His own work, which centers on the study of short-term perception, touches on these issues. Julia Kursell, for her part, is investigating the influence of Helmholtz's groundbreaking studies of sound perception and the physiology of hearing on avant-garde art. The way scientists worked then was modern and international; even the war between Germany and France from 1870 to 1872 only briefly interrupted scientific communication: the scientists traveled throughout Europe, working wherever the equipment was available, and communicated in three to four languages. "In those days, people were at the forefront; science was driven by personalities. Today, it is driven by institutions," explains Schmidgen.

Not only was the scientific world on the move, the whole of society was, as well. Farmers were migrating to the cities in search of work in factories. Industrialization was rapidly rising – and with it, the number of people who noticed the progress but were unable to benefit from it. Mass misery, the desire for more codetermination, the emancipation of women – there were major changes afoot on the social front, too. Technological progress enabled more and more precise measuring instruments to be designed, which, in turn, extended the possibilities in the exact sciences. A cycle of innovation began, particularly in the vicinity of Berlin, where personalities like Emil du Bois-Reymond, Hermann Helmholtz and Werner Siemens came together.

However, progress was not without its victims. Like machines, animals were taken apart so that the way organs worked and nerves transmitted impulses could be studied on living subjects. Expressions of pain were rarely interpreted as pain, but more like the squeaking of a door in need of oiling, and were accepted as such. Unlike in the UK, no discussion of animal rights and vivisection was ignited in Germany. Perhaps the Germans had too much respect for science, remarks Schmidgen casually.

When Emil du Bois-Reymond was finally able to take up his research work in the new physiological institute in the center of Berlin, the neighbors complained about the dogs' unbearable howling. Du Bois-Reymond was forced to switch to experimenting on rabbits and frogs. Elsewhere, scientists simply severed the animals' vocal chords. Eager for knowledge, scientists even experimented on human beings, healthy or sick, living or dead, with alternating and direct current, blood pressure measurement, artificial respiration and other tortures administered under the guise of treatment.

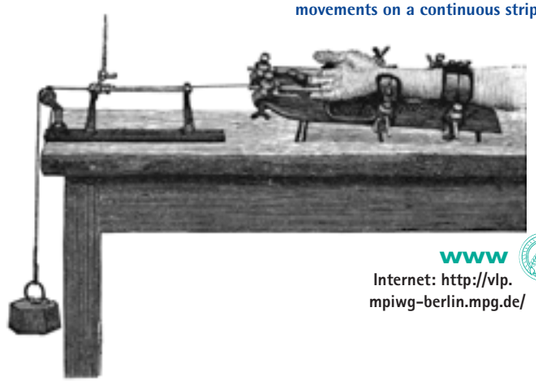
Curio cabinet and treasure trove

To the amateur, the VL represents a huge cache of curiosities. For scientists, however, it is a research tool with which they can play out even outlandish working hypotheses. The VL provides them with a quicker and easier way of viewing countless manuscripts, refuting claims, making connections. In the myLab section, they can hold the manuscripts they are working on, prepare hypotheses and subsequently review them. In the process, they might even end up submitting a piece of work that adds to the controlled growth of the VL.

The VL is accessed more than 3,000 times a day. Its users include museums, private persons, science historians and students. For legal practitioners, too, not to mention philosophers, scientists from the fields of medicine, biology and physiology, and journalists, the VL is a treasure trove of ideas for interesting lectures and essays. "Everything is available simultaneously and in parallel, and this promotes new ideas and provides impulses for the development of new research issues," says Julia Kursell.

ANTONIA RÖTGER

This classic experimental setup was used by late-19th century physiologists to study fatigue: With one finger of a hand that was otherwise fixed in position, the test person had to repeatedly lift a weight. The pen – left in the picture – was used to record the movements on a continuous strip of paper.



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