The Lesson of Claude Bernard (1813-78) or, Session at the Vivisection Laboratory, 1889 (oil on canvas), painted by Leon Augustin Lhermitte, (1844-1925).
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On the rue des Écoles in Paris, adjacent to the Sorbonne but entirely independent of it, sits the nearly 500-year-old Collège de France, an institution historically committed to fundamental research.1 In front of the entrance stands a statue of Claude Bernard. Most American tourists ask, “Who was he?” In contrast to Louis Pasteur, Bernard's student, colleague, and admirer, few Americans have heard of him. In fact, Claude Bernard taught us how to investigate biology, laid the foundation for scientific medicine, and created an intellectual revolution in philosophy in his own lifetime. The story of his life is fascinating and full of human interest.2–5

In 1813, as Napoleon's reign was drawing to a close, Claude Bernard was born in the tiny village of St. Julien in France’s Beaujolais region. His father scratched out a living from his small vineyards, supplemented by tutoring a few local children. Claude's parish priest, engaged to teach him Latin, saw some promise in the boy and arranged for him to receive secondary education at the Jesuit collège (secondary school) in the big regional town, Villefranche. Claude didn't do well academically, so he spent another year at a more distant school in Thoissey. At these schools he was influenced both by Romanticism and by the writings of René Descartes, with their emphasis on the search for truth and the importance of doubt. While this combination of interests seems odd today, in fact the romantic imagination was inspired by the sense of wonder that emerged from scientific advances in the late eighteenth and early nineteenth centuries.6

At the age of eighteen Claude became a pharmacy apprentice in a suburb of Lyon, serving largely as a handyman, delivery boy, and floor sweeper. He helped to prepare Thériaque, a mixture of some sixty-odd drugs, plants, and other ingredients
that had been prescribed for 2,000 years for a variety of symptoms. He was disconcerted by the fact that there was no evidence for its efficacy and that his employer threw leftovers from other prescriptions into the mixture.

Claude used his one night off a month to attend the theater in Lyon, which inspired him to write a successful light comedy that earned him 100 francs. Encouraged by this success, he started work on an ambitious five-act historical drama entitled *Arthur de Bretagne*. Shortly afterwards he made a foolish mistake in the pharmacy, and by mutual consent his apprenticeship was terminated.

Back on the farm he polished his play. His mother had a friend whose illegitimate son (by the king’s father, thus he was the king’s half brother) was Minister of Public and Historic Buildings in Paris. Mme. Bernard obtained a letter of introduction for Claude. Armed with this letter, Claude, a
twenty-one-year-old provincial, set off for Paris after the grape harvest, manuscript in hand, hoping to become an acclaimed playwright. The minister referred him to France’s leading literary critic, Saint-Marc Girardin. Girardin evaluated the play, found it mediocre, and told Claude: “You have not the temperament of a dramatist, you have done some pharmacy, study medicine.” 10

After some hesitation, Claude followed this suggestion. To enter medical school, he first had to pass the baccalauréat exam, which he barely did on his second try. Although some of the traditional approaches to medicine were beginning to be questioned at the time, 7,8 the profession was largely empiric, bound by tradition, and still in thrall to the humoral theory of disease. 9 Oliver Wendell Holmes was correct a few decades later when he stated that “if the whole materia medica, as now used, could be sunk to the bottom of the sea, it would be all the better for mankind,—and all the worse for the fishes.” 10p39

Bernard began his clinical studies at the age of twenty-three, but found the lectures at the medical school boring and didactic. He pestered his teachers about the treatments they espoused, demanding proof of efficacy. In contrast, he found the research-based lectures at the Collège de France exciting, particularly those of François Magendie, professor of Experimental Medicine and a pioneer in experimental physiology. 8 Bernard lent a hand in preparing anatomic specimens for these lectures. He had superb dissecting skills and was hired as Magendie’s research assistant in 1841. He pursued a few of his own research ideas in the lab, but since Magendie was not entirely happy with this, Bernard found a cellar in which to do his experiments—coincidently across the courtyard from the site where Dr. Guillotine had tested his new decapitating machine on sheep a half century earlier. Bernard was imaginative and intuitive and made some interesting findings related to glucose absorption from the gut that became the basis for his MD thesis.

In the end, Bernard didn’t think much of what he had been taught in medical school. He concluded that medical practice was not for him, and decided to commit his life to research. Easier said than done—at the time, there was no such thing as a full-time career in experimental medicine. To pursue any research at all Bernard needed an academic post, but he failed the relevant competition and faced the prospect of life as a village doctor. At this point, two friends intervened. They knew a successful society physician, Henri Martin, with an unmarried daughter who would come with a nice dowry. An arranged marriage would allow their friend to pursue his research. Bernard was surprised by the suggestion, but agreed—it was the only way he could pursue a research career. He was thirty-two years old when he married Fanny Martin.

Bernard achieved meteoric early success in the laboratory. Among his major discoveries was the finding in 1848 that there was something in the liver from which glucose could be formed, a substance he named glycogen (sugar-forming). 11,12 (The critical molecular steps in this process were defined nearly a century later by Carl and Gerty Cori of Washington University in St. Louis, for which they received the Nobel Prize in 1947.) In addition, he described the role of the pancreas in digestion, the central role of the nervous system in regulation of body temperature, and the control of heart function by the vagus nerve. At the age of thirty-six, he was awarded a prize in experimental physiology from the Académie des Sciences.

Bernard was asked to fill in for Magendie’s lectures at the Collège during the summer of 1847. He famously began his first lecture:

The scientific medicine which it is my duty to teach you does not exist. The only thing to do is to lay the foundation upon which future generations may build, to create the physiology upon which this science may later be established. 13

In the end, he accomplished just that.

In 1854 a chair in General Physiology was created for Bernard at the Sorbonne. An awkward lecturer, he did not enjoy the job, which consisted of lecturing to undergraduate students from a fixed prescribed curriculum. In contrast, when he lectured at the Collège de France, he enthusiastically presented his findings and their significance. The next year Magendie died, and Bernard was appointed to his chair. His lectures there captivated the members of his audience who, increasingly, came from every walk of life and from every corner of the earth.

Not surprisingly, his was not a happy marriage. “In order to become a physiologist” he wrote, “one must live in the laboratory.” 3 His wife Fanny did not understand him; she wanted him to follow in her father’s footsteps and become a prosperous physician. Bernard’s experiments largely involved vivisection, still a new and unpopular idea. Fanny became an ardent anti-vivisectionist—she denounced him to the police, threatened to commit suicide unless he stopped, and turned his daughters against him, enlisting them in anti-vivisection demonstrations. Every fall Bernard returned to St. Julien to see his mother and help with the grape harvest, but Fanny rarely went with him. Bernard’s family moved to a larger apartment in 1869, but he went home only to eat and sleep. In 1869 he and Fanny legally separated.

In 1864, with Louis Pasteur, Bernard was invited for a weekend to the Imperial Château at Compiègne. There, over the course of two hours, he explained his work to Emperor Louis Napoleon, who was impressed: “You are a great man of science.” 2p127 He developed a lasting friendship with the Emperor’s cousin, Princess Mathilde, and his visits to her salon enabled him to meet many prominent people, including architects, engineers, artists, and philosophers. He became a close friend of the philosopher Ernest Renan. At the age of fifty-nine, Bernard was chosen to be the first president of the French Association for the Advancement of Science, an acknowledgment, said the press, of his status as the foremost scientist of France. He was apparently a gentle, kind person. His greatest
student, Paul Bert, commented on his kindness, simplicity of soul, and naive generosity. Louis Pasteur said of him: “a great gentleness, and amiable kindness.”

So in what did his greatness lie? In addition to the many specific facts he uncovered, he made three broad major contributions. The first dealt with the doctrine called vitalism. Before Bernard’s work, it was widely held that living things were not governed by the same principles that governed chemistry and physics. It was felt that a mysterious supernatural influence, a “vital spark” distinct from physicochemical forces, played a central role. If true, this would have rendered scientific investigation extremely difficult, at best. The cumulative effect of Bernard’s work was to demolish vitalism. He showed that the phenomena of life were as determinable and definable as those of the other sciences.

Undoubtedly his most important scientific contribution was his recognition that our cells live in a fairly constant internal environment—the milieu intérieur. Regardless of environmental fluctuations or challenges, the fluid that bathes our cells—interstitial fluid—changes very little. Bernard’s initial insight into this topic was published in 1857 and subsequently evolved:

The blood constitutes an actual organic environment intermediary between the external environment in which the complete individual lives and the living molecules which cannot safely be brought into direct contact with this external environment.

And in a compilation of lectures published soon after his death in 1878, Lectures on the Phenomena of Life Common to Animals and Plants, he arrived at this sweeping, but accurate, generalization:

all of the vital mechanisms, however varied they may be, have always but one goal, to maintain the uniformity of life in the internal environment.

The great British biologist J. B. S. Haldane reflected: “No more pregnant sentence was ever framed by a physiologist.”

This concept was, however, way ahead of its time and not seriously pursued until the early part of the twentieth century, when Joseph Barcroft in England and Lawrence J. Henderson and Walter B. Cannon at Harvard expanded on it and began to define the mechanisms by which the constancy of the milieu intérieur was maintained. Under the term homeostasis, coined by Cannon in 1926, this subject established the agenda for physiologists for the ensuing two generations. The preface to the French edition of Cannon’s great book on the subject, The Wisdom of the Body (1932) states:

The central idea of this book . . . is directly inspired by the precise views and deep understanding of the eminent French physiologist Claude Bernard. This book can even be considered a tribute to his memory.

Finally, as Bernard grew older his attention increasingly turned to broad biological issues and to the philosophical implications of his approach to research, culminating in his masterwork, An Introduction to the Study of Experimental Medicine, published in 1865. This book consists of essays on his philosophy of the experimental method and discussions of how to carry out biological experimentation. He illustrated his general principles with experiments from his own laboratory. Metaphysical or teleological questions of why something happened were disdained—not why, but how. In this volume he stated:

The experimental method is the scientific method which proclaims the freedom of the mind and of thought. It not only shakes off the philosophical and theological yoke; it does not even accept any personal scientific authority. This is by no means pride and boastfulness; experimenters, on the contrary, show their humility in rejecting personal authority, for they doubt their own knowledge also and submit the authority of man to the authority of experience and of the laws of nature.

Today we take this approach for granted. At the time, it was a game changer.

Bernard insisted on experimentation as the criterion for validity. Thus, one of his students, Silas Weir Mitchell, who went on to found the study of neurology in America, remembered a conversation:

I recall one remark of Bernard’s. I said, “I think so and so must be the case.” “Why think?” he replied, “when you can experiment. Exhaust experiment and then think.”

What was Bernard’s approach to truth? In An Introduction to the Study of Experimental Medicine he states:

When we meet a fact which contradicts a prevailing theory, we must accept the fact and abandon the theory, even when the theory is supported by great names and generally accepted.

So how should one proceed? First, a hypothesis is suggested by an observation, or alternatively, by intuition or imagination, both of which Bernard valued. An experiment to test that hypothesis is then performed. If the findings support the hypothesis, they must then be found to be reproducible. If they are, the hypothesis was promoted to a theory. And what is a theory?

Theories are only hypotheses, verified by more or less numerous facts. Those verified by the most facts are the best; but even then they are never final, never to be absolutely believed.
We sometimes forget that Bernard warned us against drawing absolute conclusions. He elaborated on this point:

When we propound a general theory in our sciences, we are sure only that, literally speaking, all such theories are false. They are only partial and provisional truths which are necessary to us, as steps on which we rest, so as to go on with investigation.  

Science owes its authority to the fact that it is self-correcting, always a work in progress.  

*An Introduction to the Study of Experimental Medicine* had an impact not only on science, but on philosophy and the history of ideas as well. In that volume Bernard confronted the philosophic issues that arose from his approach to truth. Philosophy—the love of wisdom—had embraced the whole field of knowledge for centuries. Science began as a branch of philosophy—natural philosophy. The early fathers of the modern scientific method such as René Descartes and Francis Bacon were regarded as, and saw themselves as, philosophers. But by the mid-nineteenth century science was distancing itself from the traditional rational approach of philosophy—critically thinking things through—by adding a requirement for data for empirical verification. Bernard put it well: the experimental method is nothing but reasoning by whose help we methodically submit our ideas to experience,—the experience of facts.  

Writings about the methods of science were regarded as highly relevant to philosophy. In 1913, on the centenary of Bernard's birth, the philosopher Henri Bergson stated that the impact of *An Introduction* on his era was somewhat comparable to that of Descartes's great work, *Discours de la Méthode*, on the seventeenth and eighteenth centuries. Bernard's work was translated into a dozen languages and used in courses on physiology and philosophy for another century—and still warrants reading today. In the introduction to the 1957 edition, ninety-two years after its original publication, I. Bernard Cohen, Professor of the History of Science at Harvard, stated that it was "as splendid a statement of the basic features of scientific research as has ever been written." At the age of fifty-five Bernard was elected to a seat in the prestigious Académie Française on the basis, not of his scientific contributions, but of his literary and philosophical work. And the application of Bernard's approach ultimately had greater practical results than even he could guess. The literary figures Edmond and Jules de Goncourt mockingly satirized the long-term consequences of the use of his method with bizarre possibilities deemed inconceivable: after one hundred years one would be able to make laws for organisms and carry out creation in competition with the creator himself. In fact, laws for organisms have been defined and efforts to achieve the latter goal are currently under way.  

Louis Pasteur (1822–1895), nine years younger than Bernard, audited Bernard's lectures in the early 1860s. They became friends and colleagues; Bernard helped Pasteur in his studies to debunk the idea of spontaneous generation and they worked together in a futile attempt to investigate the cause of a cholera outbreak in 1865. Speaking of Bernard, Pasteur quoted the chemist Jean-Baptiste Dumas: "Bernard is not a great physiologist. He is physiology itself." An appreciation of Bernard's contributions, entitled, "Claude Bernard, the importance of his writings, teaching and method," was published by Pasteur in 1866, in which he praised *An Introduction to the Study of Experimental Medicine* as a masterpiece.  

But why do we know Pasteur and not Bernard? Pasteur, domineering, inflexible, dogmatic, was an aggressive self-promoter, obsessed with how posterity would regard him. He focused on practical issues that would soon pay off with useful or profitable applications. Bernard, in contrast, was taciturn, modest, retiring, and constantly beset by doubts. He was interested in neither utility nor profitability. His goal was to make medicine rational and scientific. All he wanted to do was to understand how the normal body functions, without which, he felt, one could not understand the diseased body. The research methods that he established, rather than benefiting the public directly, would benefit subsequent investigators.

When Bernard died in 1878, France gave him a state funeral,
the first scientist to be so honored. A cortège of over 4,000 followed the hearse from the church of St. Sulpice to the historic Père Lachaise cemetery. His friend Ernest Renan was elected to Bernard’s seat at the Académie Française and, on taking his seat, delivered the traditional eulogy of his predecessor. He described Bernard as having had a life wholly devoted to the truth and indicated that Bernard was aware that his work bore on fundamental philosophic issues.\(^\text{21}\)

Bernard had never abandoned his hope of being recognized as a dramatist. About a year before he died he entrusted a young friend, George Barral, with his forty-three-year-old manuscript *Arthur de Bretagne*. He gave permission to have it published, but not until at least five years after his death; it was ultimately published in 1887. Bernard had stipulated that this note appear in the publication: "Read and refused, with many corrections, by Saint-Marc Girardin in November 1831." Two years after it was published, however, Bernard’s wife and daughters brought suit. They felt that George Barral’s introduction was defamatory when it stated that they had left him "in a cruel state of abandonment" in 1869. The suit was successful; a court ordered that all copies of the book be destroyed.

So, in addition to the statue mentioned at the beginning, how is Claude Bernard memorialized? A plaque identifies the site of his laboratory at the Collège de France. One of the major universities in Lyon is named after him, and his statue stands there as well. But what is his true monument? Let me draw a parallel with Sir Christopher Wren, who designed St. Paul’s Cathedral in London. Under its dome sits a commemorative plaque marking his burial site. On it is written: *Lector, si monumentum requiris, circumspice*—Reader, if you seek his monument, look around you. Of Claude Bernard, one might similarly say: If you seek his real monument, look around you—at the state of knowledge of the biomedical sciences and the capabilities of medicine today.

It’s really not such a tragedy that he wasn’t a very good playwright.

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**References**


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