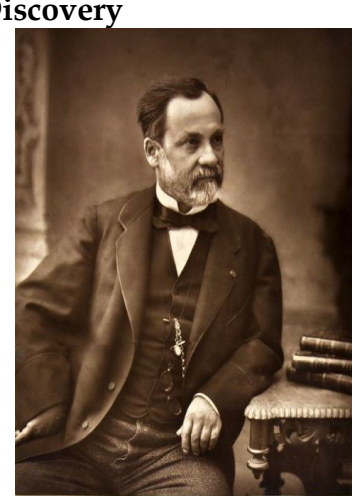
What is Life? The Passionate Dedication of Louis Pasteur
Part II by Denise Bouchard Ham and Roger Ham

The Extraordinary Years of Discovery



Louis Pasteur ~1880

Despite a near-fatal stroke in 1868 at the age of 45, which left his left side paralyzed, Pasteur's greatest achievements lay before him. The power of his insights into the nature of germs and disease exploded. His laboratory was buzzing with activity, and the breakthroughs were only limited by the time and energy required to find a solution to each new disease tackled. Between 1877 and 1888, Pasteur discovered the existence of six different species of pathogenic microbes in humans and animals: septic *Vibrio* (septicemia), *Staphylococcus*, *Streptococcus*, bacillus of chicken cholera, swine fever, and *Pneumococcus*.

"We must find out how to immunize against the diseases for which we have isolated the virus. Just as one can protect man from smallpox, why shouldn't we protect him from other epidemic diseases?" — L. Pasteur[1]

THE IDEA OF VACCINATION

The idea of using a small dose of something harmful to develop a resistance to it was known for centuries. The advent of the microscope and germ theory opened the door to new potentials in meeting the challenge: how to deliberately expose a person to a dangerous disease without killing them.

Mithridates VI, the King of Pontus (the Black Sea area and present-day Turkey), lived from 134-63 B.C. and was known to drink various potions containing small doses of poisons to develop a tolerance. The word Mithridatism refers to this partial immunity. There were also confirmed reports from Styna, a region of Poland, where heavy concentrations of arsenic occurred in the soil, allowing men and animals in the region to develop some tolerance to the poison. Small doses of arsenic can stimulate the liver to produce enzymes which inactivate its effects. It was known that snake handlers could become immune to the serpent's venom after numerous bites, and the same could be said of bee-keepers. It was also known that a person could contract a mild case of a disease and survive, maintaining immunity to the same disease in the future. The story behind the development of immunity to smallpox is key for Pasteur's later advances.

1 Pasteur Vallery-Radot, p. 144.

A child in Bangladesh with smallpox, 1973

Smallpox had plagued civilization for at least 10,000 years. Typically, one-third of those infected died, and smallpox caused a third of all blindness. Among children the death rate was as high as 80%.[2]

<BOX> Inoculation Against Smallpox

Direct injections of smallpox in a controlled manner (variolation) had been reported in China and India for centuries. Although still dangerous, if the "donor" had only a mild case, the odds were fairly good that the recipient would survive and then maintain immunity. Such inoculations were being performed in Constantinople by 1700 and were introduced into Europe soon thereafter. During the Boston smallpox epidemic of 1721-1722, a clergyman and early American patriot, Cotton Mather, and a physician, Dr. Zabdiel Boylston, introduced inoculation against smallpox into the New World against tremendous opposition, including assassination threats. Boylston communicated his inoculation experiences to the Royal College of Physicians and the Royal Society of London in 1726. The State of Massachusetts subsequently released a public health law, the "Act to Prevent the Spreading of Contagious Sickness." These important contributions to the control of smallpox are not sufficiently recognized. The work of these two "forgotten persons" in the history of smallpox was significant in its own right and it seems likely to have played an important part in the rapid acceptance in America of Edward Jenner's vaccination techniques 70 years later.

George Washington, who himself suffered a severe case of smallpox at the age of 19, scarring his skin for life, in 1777 ordered all new recruits to be inoculated for smallpox as soon as they joined the army. The death rate from such variolation was relatively low.

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About a century before Pasteur's work, English physician Edward Jenner had observed that milkmaids did not generally contract smallpox. He hypothesized that the milkmaids contracted the less virulent cowpox, and were protected by it from the deadly smallpox. On May 14, 1796, Jenner tested his hypothesis by inoculating the 8-year-old son of his gardener with material from the blisters on the hand of a milkmaid who had caught cowpox. The boy developed a fever but no great illness. Jenner later injected him with smallpox material, proving that the boy was now immune. Despite this success, Jenner's inoculations met with opposition from the British Royal Society and others.

2 Over the course of the 20th century, as many as 300-500 million people died from this single disease.

A British satirical cartoon of Jenner's cowpox inoculations

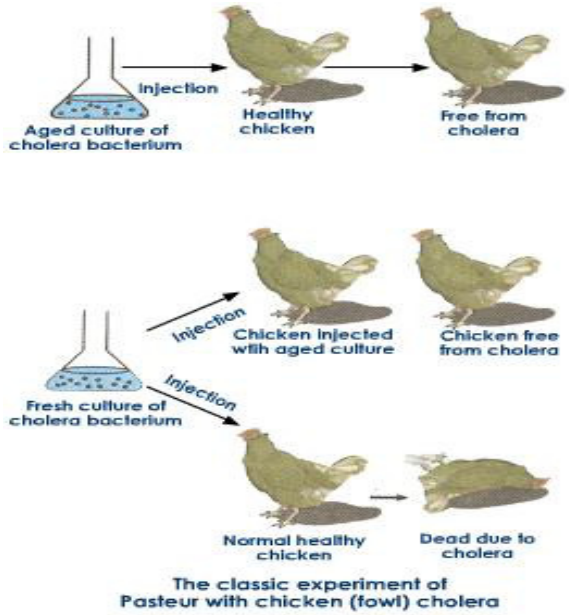
Two centuries later, smallpox was finally declared eradicated worldwide in 1979 after a coordinated campaign of vaccination.[3]

Chicken Cholera

"In the field of experimentation, chance favors the prepared mind." -Louis Pasteur

It was a happy accident that allowed Pasteur to build on this work using *inoculation* (the use of a naturally occurring weakened microbe, as in the case of smallpox) in order to develop what would be called *immunization* (the use of an artificially weakened microbe). In 1879, while studying chicken cholera, he instructed his assistant, Charles Chamberland, to inject some chickens with cholera while Pasteur left the laboratory to go on holiday. Chamberland failed to do this, and instead went on holiday himself. Returning a month later to find a flask of the microbe that had been prepared before he had left, Pasteur, rather than discarding it, decided to use it. As it happened, the microbes had weakened or attenuated, due to aging and exposure to oxygen, and when Pasteur injected the culture into healthy hens, they not only survived, but became immune to the disease. Over and over he did the experiments, also using rabbits and guinea pigs, and discovered that he could create a weakened microbe which enabled him to immunize these animals.

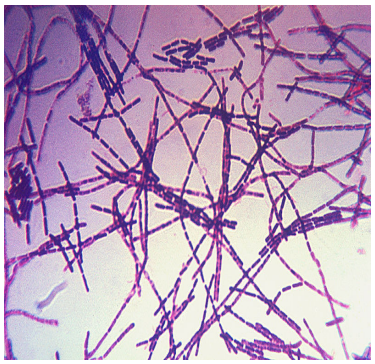
3 Only one other infectious disease has ever been declared eradicated, that being the cattle disease, rinderpest, in June of 2011.



An illustration of how an aged culture of chicken cholera conveyed immunity

Thus was created the first laboratory-produced vaccine.[4] While much had to be discovered regarding exactly how the vaccine triggered a response by the immune system, Pasteur's breakthrough opened the potential for developing vaccines against all the diseases which plagued mankind. But this is not as easy as it sounds! Pasteur discovered that each disease, each microbe, was unique: a method to weaken one microbe was useless with another; a weakened microbe might immunize one species of animal and still kill another. To find a point of attack against the microbe, he had to develop a complete understanding of its life cycle and conditions of growth.

The Scourge of Anthrax


Bacillus anthracis

To fully appreciate the public triumph of Pasteur and his young associates, it is necessary to understand the economic devastation as well as the challenges in solving the problem of anthrax. One of the oldest diseases of grazing animals, it reproduces rapidly within an infected animal and releases two powerful toxins that can kill within a few days or weeks. After the animal dies, the bacillus can form soil-borne spores which are extremely difficult to eradicate. Heating, harsh chemicals, and burial do not kill these spores.

4 Pasteur acknowledged the importance of Jenner's work with cowpox by describing all such inoculations as vaccines. The Latin root *vacca* means cow.

The anthrax microbe had first been identified by Casimir-Joseph Davaine in 1850. He was able to show that it could be transmitted from one animal to another, but was unaware of its life cycle and mode of action. Robert Koch, one of Germany's great physicians, was the first to make a thorough study of anthrax. Of crucial importance, his study of the spores which anthrax can form uncovered the full life cycle of the disease. [5]

In 1877 French farmers begged the government to send someone who could stop the contagion. The government called on Pasteur to discover a method to stop the spread of this ancient killer. The challenge far surpassed anything he had undertaken before, but he cheerfully undertook the project, along with his two young doctor recruits, Roux and Chamberland.[6]

First, the team determined independently that anthrax was not transmitted from one animal or person to another directly, but through the intermediary of its exceptionally resilient spores, which could remain dormant in the soil for decades after farmers buried their dead cows, sheep, or horses. If the spores were brought back to the surface by burrowing earthworms or other means, they could be consumed on the grassy fields and pastures by grazing cattle, reproduce rapidly in their new hosts, and kill again.

Pasteur was able to distinguish both the cause and the lethal products of anthrax, but a cure or preventive measure was needed. Familiar with Jenner's work on inoculation, he saw a possible means to protect animals.

Having confirmed that anthrax was transmitted via spores, Pasteur attempted to weaken them as he had done with chicken cholera bacteria, but the spores remained unchanged and virulent. After many experiments, he found that by cultivating the anthrax bacteria at precisely 108° F (a "high-fever" temperature), he could prevent the formation of spores and produce weakened bacteria by infusing oxygen into the culture. The weakness was then transmitted to successive generations of bacteria cultivated at normal body temperature, and in early 1881 a vaccine was produced.

An anecdote from this period reveals Pasteur's courageous commitment to scientific truth. In the course of experiments, he was amazed to discover that chickens were seemingly immune to anthrax and that one could not successfully infect them with the microbe. Why should that be? What could he learn about the microbe by studying which animals were affected; what were the conditions that increased or retarded the spread of the disease; why did epidemics end of their own accord, and why did some diseases, like anthrax, reappear after seemingly disappearing?

One of the most bitter opponents of Pasteur and the germ theory of disease was Gabriel Colin, a professor of veterinary studies. Because he could not "see" a microbe, Colin rejected the germ theory in favor of some other, soluble, undetermined agent, in dealing with anthrax. This was in line with the idea of a miasma or some sort of chemical, which caused infection.

Pasteur would not tolerate fools, especially stubborn, obstinate fools, and, speaking to an audience of scientists, he said this: "You young people who sit in the upper tiers of this amphitheater... and who may represent the hope for our country's medical future, do not come here to look for the excitement of polemics; come to learn about methods. Well, I am giving you as an example of the most detestable of these methods M. Colin's statement that a negative microscopic observation is sufficient to assert that there is... an anthrax virulence without any presence of

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5 Koch felt that Pasteur had ignored his work, and that he, Koch, deserved the fame. According to Elie Metchnikoff, the great Ukrainian-Russian embryologist, who started work with Pasteur in 1885, it is probable that Pasteur was unaware of Koch's work. Pasteur praised the younger physician-biologist, and he even invited Koch to an open forum to discuss anthrax, but Koch refused to attend. His views did change after Pasteur died. Koch's highly original work led to the discoveries of the bacteria that caused tuberculosis and cholera. In 1905 he won the Nobel Prize in Physiology or Medicine for his work on tuberculosis—one of the greatest scourges of Europe at the time, which would go on to claim millions of lives until a human vaccine was developed in 1954.

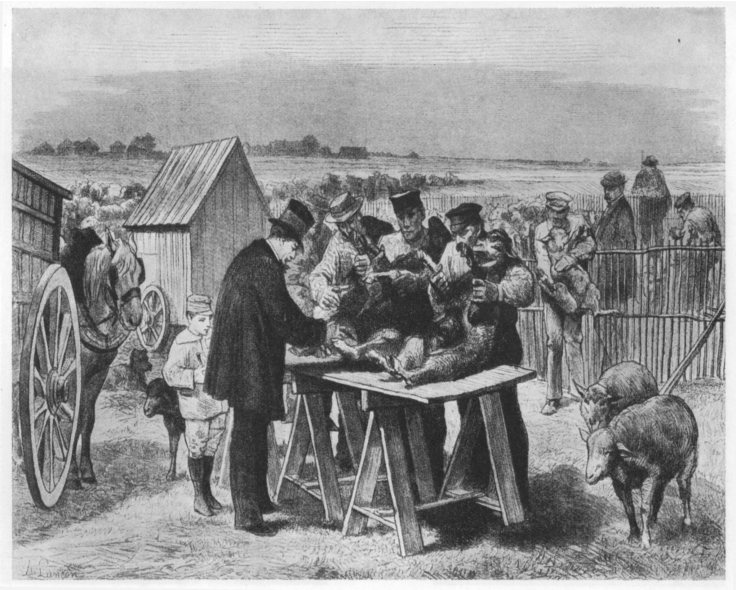
6 After Pasteur's death, Emile Duclaux headed up the Pasteur Institute. Roux became the second to lead the Institute using his mentor's methods. Roux also worked closely with the Curies on radioactive elements, and Pierre Curie's earlier work in crystals.

bacteridia in the inoculated material."[7]

When Pasteur stated that chickens could not be infected with anthrax, Colin immediately insisted the opposite. Pasteur challenged him to produce such infected animals. Every week they would see each other at the Academy of Science, and Pasteur would ask, "Where are my chickens?" Colin repeatedly gave excuses, but finally admitted that he couldn't produce them.

Pasteur was glad to have temporarily silenced Colin, but the immunity mystery remained. He hypothesized that the higher body temperature of fowl, especially chickens, prevented the reproduction of the anthrax microbe. Immediately, Pasteur told Colin that he, Pasteur, could infect chickens with anthrax! He succeeded—by placing the hens in a bath of cold water, thus lowering their body temperature.

The Grand Experiment



Pasteur in Pouilly-le-Fort

The controversy, however, was hardly over. The number of scientists who jealously wanted to see him fail far outnumbered his allies, and included such famous scientists as Koch. No sooner had Pasteur and his assistants announced their success with the weakened anthrax bacteria than a veterinary surgeon and editor by the name of Rossignol publicly challenged Pasteur to prove that he could vaccinate farm animals against anthrax. Pasteur accepted. On the morning of May 5, 1881, the town of Pouilly le Fort where the event was held more resembled a carnival than the site of a scientific experiment. Farmers from all over the region, and newspaper men came to watch this "show." Bets were taken from all over France, most of the wagers against Pasteur, despite his reputation as the nation's most brilliant scientist. Pasteur was accompanied by his young associates: Emile Roux, Louis Thuillier, and Charles Chamberland.

The center of attraction was 60 farm animals, mostly sheep, with a few cows and a goat: The animals were randomly assigned to two groups of 25, and one control group of 10 animals. Shortly before the experiment began, one of Pasteur's detractors, in an attempt to spoil Pasteur's chance for success, grabbed the flask containing the weakened microbes and shook it, because he had heard that

7 Debré, p. 311. *Bacteridia* was a specialized term, referring to the the rod-shaped bacteria associated with anthrax.

the germs could settle to the bottom of the flask. He then returned the flask and announced that Pasteur would fail. Calmly, Pasteur's team vaccinated Group One with the attenuated anthrax microbes, and these animals were marked on the ear. Nothing was done to Group Two or the control group. About two weeks later, everyone returned to Pouilly le Fort—farmers, physicians, pharmacologists, veterinarians, and reporters. This time Pasteur's team injected Group One with a second, more virulent dose of anthrax, and then, in late May, he injected all the animals of Groups One and Two with the full-strength anthrax microbe. Several days later, he received a telegram that the unvaccinated animals of Group Two were dead or dying, while all the vaccinated animals of Group One were in good health, except one. This one ewe gave the anti-vaccinarians hope to dispute Pasteur, but a necropsy proved that it had died of a miscarriage, not of anthrax.

Pasteur's method was vindicated. In 1882, in one department of France alone, 80,000 sheep were vaccinated and losses due to anthrax plummeted from 9% per annum to one-third of 1%. After his public success in France, he was invited to demonstrate his vaccination methods in Hungary, which were, again, a complete success. As a result, Hungary became a major provider of meat to Central Europe.

Following his May success, Pasteur was asked by the government to represent France at the International Medical Conference in London, where he would be the only non-physician.[8] Pasteur was greeted with thunderous applause by the attendees. During the conference, Joseph Lister, a champion of antiseptics and sterilization alongside Pasteur, came under attack from a Doctor Bastian, who insisted that "the microscopic organisms in diseases are produced in the tissue themselves." Pasteur wrote to his wife, "that was enough for me, and I took the floor to bear down on him. He will have a hard time recovering from this."[9]

Pasteur was sent many honors, but refused them if they did not include his associates, especially Chamberland and Roux, who he deeply felt deserved as much credit as he.

Conquering Rabies

A rabid dog

By 1880, Louis Pasteur's preeminent position as a scientist gave him the freedom to choose his challenges. While he continued his work on bacteridia and vaccination, his new challenge was rabies. This was a personal project for Pasteur. It is said that Pasteur, while growing up in the town of Arbois, at the age of twelve, witnessed a rabid wolf bite ten victims, eight of whom died of rabies. While there were fewer than 500 reported cases in France in any given year, rabies caused such a horrible death that it had a profound and terrifying effect on anyone who witnessed it. Rabies is also known as

8 Although he had been inducted into the Academy of Medicine in 1873.

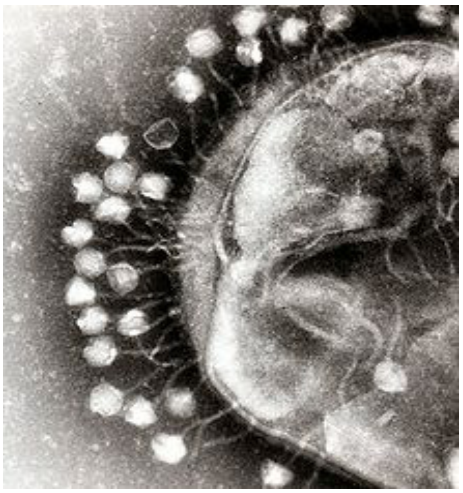
9 Debré, p. 402.

"hydrophobia," meaning "fear of water," because in the middle to last stages of rabies, the unfortunate victim could not drink water, though he thirsted for it, and could eat no food. The victim of a rabies attack became like the mad dog. He would froth at the mouth, and die in excruciating pain as the disease traveled through the central nervous system to the brain.

Some people tried to treat a rabies bite by going to a blacksmith and having a red-hot poker inserted into the wound. This only worked on the most superficial bites and if done immediately after the attack. In most cases this method failed, leaving the dying victim in greater pain. If there were multiple bites and piercing through much flesh, the victim was doomed.

Pasteur studied rabies, not only because its symptoms were horrible, but also because the wide variation in symptoms and progression of the disease made it very mysterious. A success here would be a powerful proof of Pasteur's immunization procedures.

How can you fight a microbe you can't even seen?



A bacteria being attacked by much smaller virises

As was mentioned earlier, some bacteria could be seen even with the crude microscopes of van Leeuwenhoek. Bacteria, such as anthrax, *E. coli*, *Staphlococcus*, cholera or tuberculosis, generally range from 0.5 to 5 micrometers in size. A micrometer is a millionth of a meter or a thousandth of a millimeter. They are so numerous that their biomass may exceed that of all plants and animals on Earth. Your body is composed of about 25 trillion cells, but is a host for 100 trillion bacteria on and inside your body, mostly in your gut, digesting your breakfast. We know today that rabies, smallpox, influenza, measles, polio and many other disease agents are not bacteria, but instead are viruses. This is a totally different class of organisms, much simpler and lacking the capacity to reproduce themselves independently. A virus must invade a host cell and take over the cell's own internal functions to produce the components of a new generation of viruses. Because of this simplicity, a virus is usually much smaller than a bacteria, ranging from about 10 to 300 nanometers (billionths of a meter or millionths of a millimeter). One of the many Rhinoviruses that cause the common cold is so tiny that 500 million can fit on the head of a pin! This extraordinarily small size made it impossible to "see" the virus with even the most powerful optical microscope's magnification of about 1000. In fact, it was only after the invention of the electron microscope in 1931, with a magnification today exceeding one-million-to-one, that viruses could be observed directly.[10]

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10 This is akin to the problem that Johannes Kepler faced in his discoveries of gravity, and the ordering principle of the universe. Kepler never had a telescope to see the heavens and was plagued by bad eyesight, yet he correctly understood that one had to see the universe as if through the mind of the Composer of the universe.

In order to rigorously study the life cycle and conditions of growth of a microbe, it was necessary to find a medium in which it would grow outside of an animal or person, providing a consistent supply of the microbe under strict control. (Today, most influenza vaccines are still produced using chicken eggs as a growth medium for the virus.) In the case of rabies, it was found to be impossible to grow the rabies microbe outside of a living organism, and numerous dogs, rabbits, and monkeys had to be sacrificed in the effort to understand the disease.

Pasteur hypothesized that an attenuated germ might be the answer to this disease as it had in chicken cholera and anthrax. Pasteur, who had suffered a stroke in 1868, needed the help of his cadre, Roux, Chamberland, Duclaux, and others, who were responsible for conducting the actual experiments under Pasteur's direction.

Stray dogs were caught and deliberately infected with rabies to study the course of the disease. Efforts to harvest the microbe from the saliva of a rabid animal or, later, the blood, were unsuccessful in transmitting the disease.

Since it was noted that the central nervous system and the brain were affected at the end, they tried to use nerve tissue inserted under the skin of the test subject. Sometimes this resulted in infection, and sometimes not. The surest method to transmit the disease was by drilling a small hole in the skull of a healthy dog (trepanning) and injecting diseased brain tissue from an infected dog, an unpleasant but necessary procedure that Pasteur did not enjoy using.

Unlike his work on developing an anthrax vaccine, where he attenuated the disease, Pasteur first worked to develop a more virulent form of rabies. He reasoned that the acquired immunity would be stronger if provoked by a highly virulent germ. He injected rabies from a dog into a rabbit. The rabbit died in about fifteen days. He took tissue from this rabbit, and infected a second, healthy rabbit. Over the course of years, he repeated this procedure of passing the virus from rabbit to rabbit 90 times (!), meticulously attending to detail, resulting in a virus that could kill within only seven days. His purpose was to produce a virus of consistent potency and a technique for mass producing it. He could then, willfully, control the degree of virulence of the microbes he injected into the victim. If he passed the same rabies virus through a number of monkeys, a weakened virus would be created, which, when injected into a healthy dog, would usually protect it from infection. That would work as a prophylactic against infection, but were he to save victims already bitten, he needed a different strategy.

The hypothesis behind Pasteur's treatment of already infected individuals was based on the fact that the rabies virus from an animal bite could take weeks or months to move to the central nervous system and kill the animal or person. Pasteur hoped that by injecting a weakened form of a highly potent virus soon after the infecting bite, he could stimulate an immune response in the victim sufficient to stop the progress of the virus before it reached the brain and caused death. What finally worked most effectively in transmitting this weakened rabies virus, was injecting dried spinal cord tissue from one of the dead rabbits. The cord tissue was crushed and then dried in a sterile container. The longer it dried, the less virulent the microbe, declining over 14 days until it produced no apparent effect. Instead of a single immunization, however, a series was administered over time, each succeeding injection using a sample that had dried for a shorter period. Pasteur was able to demonstrate repeated and consistent success, even several days after an infecting bite.

A rabbit spinal cord being dried

A painting of Pasteur examining such a flask

In 1882, he wrote a paper to the French Academy of Science, most of whose members were stunned at the success of his experiments. There were also many who tried to sabotage his work, especially the "environmentalist" (anti-vivisectionist) groups in Britain who attacked Pasteur for killing or simply experimenting with animals. Needless to say, today we can vaccinate our dogs and cats to prevent them, as well as people, from contracting rabies, thanks to Pasteur's work.

It is no simple matter to create an attenuated microbe which protects a wide range of animals. Pasteur tested numerous species of animals in both his anthrax and rabies experiments. In the case of anthrax, dogs had immunity but not sheep. He found that even within the same species there could be thoroughly different responses: if both French sheep and Algerian sheep were injected with a small dose of anthrax, the sheep of France died, while the Algerian sheep were only mildly affected and then recovered.

Now the question was, would the vaccine be effective and safe for humans and could he cure a human who had already been infected with rabies?

Pasteur's decades of careful research had proven to him that his method was correct. He had successfully saved mice, guinea pigs, rabbits, dogs and monkeys from rabies, but he dared not test his treatment on a human subject; he was not even a licensed physician and could be tried for murder if the patient died. Although he considered testing the technique on himself, his wife and scientific colleagues persuaded him against it. While he was willing to sacrifice his life for science, they argued that a failure could discredit his work.

"The Greeks have given us one of the most beautiful words of our language, the word 'enthusiasm' — a God within. The grandeur of the acts of men is measured by the inspiration from which they spring. Happy is he who bears a God within." — Louis Pasteur, speech at his reception into the Académie Française, April 27, 1882.

Little Joseph Meister

Joseph Meister, the first person vaccinated after being infected with rabies

On July 4, 1885, a mother from Alsace brought to Pasteur her nine-year-old son, Joseph Meister, who had been attacked by a rabid dog just that morning and had many deep wounds. She begged Pasteur to save him.[11]

Pasteur's team of doctors, Edmé Félix Vulpian and Joseph Grancher, examined the boy and cleaned his wounds with carbolic acid. Pasteur and the doctors gave Joseph his first injection of rabies virus, 14 days old, and held their breath. They gave a total of 12 injections under the skin of the abdomen over a period of ten days, each injection more lethal than the last. Pasteur stayed by the boy all day, and at night he slept in a chair near him. Joseph grew very fond of him, and would throw his arms around Pasteur's neck to kiss him in the evening. The final injection, with the full-strength virus, was administered on July 16. Joseph recovered completely.

When Joseph Meister was finally declared "cured," he went home, but Pasteur told the boy that he expected him to correspond with him through letters. Joseph happily corresponded with him until Pasteur's death. Joseph became an employee at the Institut d'Pasteur, working as a guard. When the Nazis entered Paris in 1940 and demanded that he open Pasteur's crypt, Joseph committed suicide rather than obey the Nazis.

As word of young Meister's miraculous recovery spread, more children were brought to his door. In one heartbreaking case, a ten-year-old girl, Louise Pelletier, was brought to Pasteur 37 days after she had been severely bitten on the head. Even though the case was hopeless and treating her would only provide ammunition to his opponents, Pasteur could not refuse. The injections were performed, but the girl died one month later. Fifteen years later, her father wrote: "Of all great men whose lives I have known, Pasteur seems to me the greatest. I never met a single one who would have done what he did in the case of my little daughter—sacrifice long years of toil as a scientist, jeopardize a universal reputation, and deliberately embark upon a dismal failure, for the sake of humanity."[12]

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11 In a brief 1939 French radio interview, Joseph Meister recalled that when he and his mother arrived in Paris they had great difficulty in locating Pasteur. "At this time M. Pasteur had many enemies, especially in the world of medicine. Hospitals refused to give us his address, and wanted to keep me instead to treat me. But my mother insisted so much that they finally sent us to the Ecole Normale Superieure on d'Ulm Street where M. Pasteur was working".

12 Pasteur Vallery-Radot, p. 181.

The Boys from Newark, New Jersey

Pasteur with Mechnikoff and the four boys from Newark (still wearing bandages over their wounds)

Also in December of 1885, four young boys in Newark, NJ were going to school when all were bitten by a rabid dog. Realizing that the youth would die a horrible death, Dr. William O'Gorman (a respected local doctor) announced that the boys had to be sent to Paris to be treated by Pasteur himself, and that this sea voyage had to be financed immediately. A few philanthropists, including Andrew Carnegie (who also provided funding to Marie and Pierre Curie at the Pasteur Institute at the turn of the century), former Secretary of State Frederick Frelinghuysen and hundreds of small donations made by the public-at-large (even young children sent in their pennies), made the voyage possible. A public announcement of Dr. O'Gorman's appeal was made by the *New York Herald Tribune*:

<BLOCKQUOTE>
I have such confidence in the preventive forces of inoculation by mitigated virus that were it my misfortune to be bitten by a rabid dog, I would board the first Atlantic steamer, go straight to Paris and, full of hope, place myself immediately in the hands of Pasteur... If the parents be poor, I appeal to the medical profession and to the humane of all classes to help send these poor children where there is almost a certainty of prevention and cure. Let us prove to the world that we are intelligent enough to appreciate the advance of science and liberal and humane enough to help those who cannot help themselves.[13] </BLOCKQUOTE>

Their story was followed closely by the local and soon the national press as documented in Dr. Bert Hansen's scholarly article "America's First Medical Breakthrough: How Popular Excitement About a French Rabies Cure in 1885 Raised New Expectations of Medical Progress."[14]

The Pasteur Foundation describes the impact of this event:

<BLOCKQUOTE>
This story is the genesis of two enduring Pasteurian traditions:

First, it marked the beginning of American giving to the Institut Pasteur. In response to the

13 New York Herald Tribune, December 4, 1885.
14 American Historical Review **103**:2, April 1998, pp. 373-418.

world's reaction to Pasteur's rabies vaccine and with the contributions that began to arrive, the French Academy of Sciences established an international fund for the construction of an institute that would bear the name of Louis Pasteur. In the U.S., a small notice was published in the New York Herald Tribune and many Americans like Gordon Bennett, the editor of the paper, showed their gratitude by becoming the institute's first donors.

Second, this event marked the start of the institute's history of scientific collaboration with America. Following the visit of the Newark boys, Pasteur was pleased, for example, to welcome scientists from New York and Chicago into his laboratory to demonstrate his rabies treatment. This cooperation would give Americans quick, local access to a cure for the much-dreaded disease. By the turn of the century , at least six American Pasteur Institutes were operating and had provided Pasteur's treatment to over 2000 Americans.[15]

It was with the same cooperative spirit that, during World War I, the Institut Pasteur played an active role in the preparation and supply of vaccines and sera to the Allied Forces. The American Army and American Red Cross received some 800,000 doses free of charge.

From 1938 to 2001, the Institut Pasteur has welcomed over a thousand American researchers and hundreds of Pasteur scientists have come to the United States to pursue post-doctoral fellowships. The new Pasteur Foundation Post-Doctoral Fellowship program seeks to perpetuate this tradition by increasing significantly the number of Americans on the Pasteur campus.[16] </BLOCKQUOTE>

Despite the international praise of his work on rabies and other diseases, there still existed a nest of scientists and journalists who sought to discredit his work. According to Pasteur's grandson:

<BLOCKQUOTE>
Certain doctors and certain journalists, always on the alert for something that might erupt into a scandal, pursued Pasteur with their attacks. The death of little Louise Pelletier and that of three Russians out of nineteen who had come from the province of Smolensk to undergo antirabies treatment, unleashed a vicious smear campaign. Pasteur, it was charged, did not prevent rabies—he gave it! The public was invited to Anti-Pasteurian Meetings with topics such as "The alleged discoveries of M. Pasteur," his "heresies" and "frauds." The *Ami du Peuple* ranted: "The discoveries by Pasteur are nothing but a hoax, grafted upon the boldest lies. He cures rabies no more than he does silkworms.... He is lying, as he has lied brazenly in all his scientific reports for the past ten years."

In the *Union Libérale*, Pasteur was maligned as a "deluded individual, a degraded chemist, an object of ridicule, whose frustrations should teach a lesson to those phony scientists who meddle into subjects they don't understand."[17] </BLOCKQUOTE>

His grandson also said that Pasteur was accused of homicide. Pasteur did not realize how many enemies he had, and these constant attacks and counterattacks resulted in his health faltering. In November of 1886, (over a year after Joseph Meister was treated), he developed "symptoms of coronary insufficiency." In January 1887, he was formally attacked (*in absentia*) in the Academy of Medicine by a Prof. Peter after the death of a child who had received a vaccination. Pasteur, in Italy for some much needed rest, was defended by his students. One of his students, Prof. Vulpian, answered:

<BLOCKQUOTE>How can one help being dismayed by such accusations, hurled against a man like M. Pasteur, whose good faith, loyalty, and scientific integrity may serve as a model to his foes and

15 In the third part of this report we will discuss why the Pasteur Institutes founded in America failed.

16 Pasteur Foundation, "Historical Relations with the United States." Available at: www.pasteurfoundation.org/IP-USA.html. Accessed Dec 12, 2008.

17 Pasteur Vallery-Radot, p. 185.

friends alike? Never has M. Pasteur lost sight of the darker side of the method he created. Every time he has published his statistics, he has cited the rare cases where his treatment has not succeeded.[18]
</BLOCKQUOTE>

Despite such attacks, Pasteur and his "youth brigade" (many of them now in their 40s and 50s) earned such high accolades that the government of France began the construction of the Institut Pasteur. Pasteur, who in his younger years was forced to crawl up into the attic of the Ecole Normale where he could do experiments in the small lab he established there, was honored to have such a facility in his name.

Institut Pastuer in Paris

On Nov. 14, 1888, the Institut Pasteur was finally opened. Scientists from many countries flocked to the Institute to learn his methods. It became a teaching and research center, leading to a fresh round of discoveries. His students "Chamberland and Roux demonstrated that immunization could be effected by means of heat-killed bacteria; this is the method employed today for protection against a score of contagious diseases. Of enormous consequence was the discovery by Roux and Yersin that the filtrate of cultures of diphtheria bacilli contains an exceedingly powerful toxin, responsible for the dangerous course of the infection. This led to the discovery of antitoxins by Behring in Germany, revolutionizing the treatment of diphtheria."[19]

To that can be added crucial work on tetanus, tuberculosis, syphilis, whooping cough and many others, based on Pasteur's methods.

18 Pasteur Vallery-Radot, p. 186.

19 Pasteur Vallery-Radot, pp. 189-190. Mrs. Ham notes that her grandfather, Henri Bouchard, was one of five survivors in a family of twelve children; seven died within the period of a week from diphtheria.

Pasteur's Legacy.

Louis Pasteur being honored by his friends and colleagues at the Sorbonne on December 27,1892, his seventieth birthday. Sadi Carnot (President of the Republic) and Russia's Alexander III were present at this affair.

At this point in his life, he was stricken once more by a stroke that left him unable to speak above a whisper. His grandson, Pasteur Vallery-Radot, age 5 at this time, says:

<BLOCKQUOTE>
A grandiose ovation was staged at the Sorbonne. Representatives of the academies, the universities, and the scientific societies of France and from abroad paid tribute to him. The great Lister, speaking in the name of all physicians and surgeons, remarked that, "Pasteur had lifted the veil that for centuries had hidden the infectious diseases." When Pasteur got up to embrace Lister, there was a thundering applause in the huge amphitheater. All delegates then presented to Pasteur the citations they had come to deliver.</BLOCKQUOTE

Unable to thank the huge assembly, his son delivered his remarks to his friends and colleagues:

<BLOCKQUOTE>
You delegates of foreign countries who have come a long way to show your sympathy for France, have given me the greatest joy a man can feel who believes that Science and Peace will prevail over Ignorance and War, that the nations will learn to understand each other, not for destruction but for advancement, and that the future belongs to those who have done most for suffering mankind.[20]<BLOCKQUOTE>

Pasteur was no longer able to work. By this time he had suffered his third stroke and was weak and unable to carry out laboratory work. Pasteur spent more time with his family, but he continued to work with his younger colleagues during their frequent visits. Pasteur died on Sept. 28, 1895, and was buried in a crypt at the Institut Pasteur.

20 Pasteur Vallery-Radot, pp. 191-192.

We can learn a great deal from the life and achievements of Louis Pasteur on at least two levels. By reliving his discoveries, we can attempt to "get inside" the creative process of discovery. The long list of discoveries made by students of Pasteur attests to the power of that process. But more profoundly, Pasteur's whole life serves as an inspiration to us all. His immortality flows from his own sense that the ultimate value of his life was determined by the contributions he could make to posterity. What greater gift can we give to young people today.

Pasteur said it best, at that same birthday celebration at the Sorbonne, where he called upon the younger generation:

<BLOCKQUOTE>Young men... live in the serene peace of the laboratories and libraries. Ask yourselves first: What have I done for my education? And as you gradually advance: What have I done for my country?–until the moment comes when you experience the tremendous gratification of knowing that in some measure you have contributed to the progress and welfare of mankind. More or less favored by the current of life as your efforts may be, you must have the right to say, on approaching the great goal: I have done all I could do.[21] </BLOCKQUOTE>

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In a companion article, Pasteur and the Shape of Space, we discuss how the failure of the Pasteur Institutes created in the United States reflected what went wrong more generally within science in the 20th century. We also discuss the impact of Pasteur's work on later scientists as well as investigations of chirality being undertaken today.

21 Ibid.