Legacy of Louis Pasteur

Who is Louis Pasteur?

Louis Pasteur, a qualified chemist, was behind the most important scientific revolutions of the 19th century in the fields of biology, agriculture, medicine and hygiene. Beginning with his research on crystallography, he soon embarked on a journey that led him to develop the rabies vaccine. His life was filled with revolutionary discoveries and was also marked by events that likely fueled his desire to understand the diseases of his time. A tireless and dedicated scientist, he traveled extensively to prove his theories and solve agricultural and industrial problems caused by infectious diseases.

With a dedication to excellence in science and public services, he founded the Institut Pasteur, a nonprofit research organization, in 1887. Since Nobel Prizes were first awarded in 1901, Pasteur Institute has received ten. Louis Pasteur's scientific excellence and vision has spawned a network of 33 institutions worldwide, named Institut Pasteur International Network, devoted to public health and basic science.

The Work of Louis Pasteur

1847: Research on molecular asymmetry

After several years of research involving crystallography, chemistry and optics, Louis Pasteur drew a parallel between the external form of crystal, its molecular make-up and its effect on polarized light. He discovered that asymmetric crystals deflect polarized light, whereas crystals with a plane of symmetry do not.

He established a law of primary importance. "Only products originating under the influence of life are asymmetrical because they developed under the influence of cosmic forces which were themselves asymmetrical." Asymmetry is the major dividing line between the organic and mineral worlds.

Louis Pasteur's work led to a new science: stereochemistry or spatial chemistry. It was also behind the emergence of synthetic chemistry.

Fermentation, a Life's Work from 1857 to 1862

1857: Beginning of research on fermentation

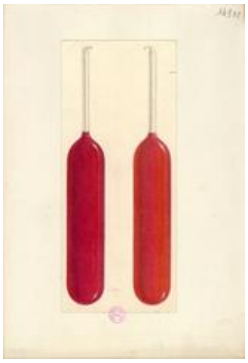
It was while observing paratartrate crystals that Louis Pasteur discovered molecular asymmetry. When examining a paratartaric acid solution, he noticed that the acid had fermented and been dissociated under the effect of mold. The fermented liquid now only contained left tartaric acid. The right tartaric acid had been decomposed or "disassembled". Thus, a substance inactive on polarized light (paratartaric acid) had become active (left tartaric acid) under the effect of fermentation.

On completion of these experiments, he established a theory that ran counter to the belief of the famous German chemist, Justus von Liebig, that fermentation was a death process. Because all active substances come from the living environment, fermentation is a life process. Only life generates substances that are active on polarized light.

Through a logical sequence of studies, it was this initial observation that led from molecular asymmetry to fermentation and then to contagious diseases.

1857: Beginning of research on fermentation

Many distillers in Lille were concerned about variations in their beetroot alcohol production and they requested that Louis Pasteur focus his research on lactic acid and alcohol fermentation.



He noted that:

- alcohol fermentation is due to a living organism – ferment
- to study fermentation you need to prepare a sterile fermentable culture medium obtained through boiling, and inoculate the medium with a trace of pure ferment

This was the basis of all microbiological techniques.

Louis Pasteur's work raised a new set of research questions, such as "Where do fermentation agents come from?" and "Do they originate from germs similar to themselves or do they appear spontaneously as explained by the spontaneous generation theory?"

Spontaneous Generation – The Big Debate

At the time, the spontaneous generation theory was widely accepted in scientific circles. Louis Pasteur decided to approach the issue using his experimental method.

He boiled water in a swan-necked flask for a few minutes until steam escaped from the open end of the flask. The water was then cooled. While cooling, the air entering the flask deposited dust and germs on the first bend of the flask. Although in contact with outside air, the liquid remained unaltered because germs could not get through.

Louis Pasteur showed that microbes were omnipresent – in water, in air, on objects, on the skin – and that some were responsible for diseases.

In his paper in 1862, he was able to claim that:

- airborne dust contained microorganisms that develop and multiply
- even the most putrescible liquids remained unadulterated if kept away from air (and hence these microorganisms) after heating

He recommended ways of preventing and fighting these germs, and thus the habits essential for personal and social hygiene. This notably included the use of aseptic procedures, i.e., measures to prevent invasion of live tissue or inert environments by exogenous microorganisms or viruses. He advocated the importance of sterilization of linen and dressings, passing instruments through a flame, and clean hands. These recommendations led to the widespread advent of modern surgery.

So How Does Fermentation Work?

Louis Pasteur continued to ponder fermentation and how ferments work. While studying butyric fermentation, he discovered a new class of living organisms, termed "anaerobic", capable of living without air. He concluded that fermentation is the consequence of life without air.

He applied his microbiological method to industry and agriculture to eradicate ancient diseases affecting crops and products.

To the Rescue of Industry and Agriculture

Wine, Beer and Pasteurization

Wine was France's flagship industry and a difficult business in many respects. Winemakers had difficulty guaranteeing the quality of their production, which was affected by diseases of no known cause or cure. This risked damaging exports and above all trade agreements with England. Emperor Napoleon III called on Louis Pasteur to seek a solution.

First he showed that each wine disease was due to a particular ferment. He developed a protocol to fight the diseases, heating the wine to between 55°C and 60°C, a temperature at which it does not deteriorate and its bouquet is preserved. This method is now known worldwide as pasteurization.

Just like wine, beer was infected by microorganisms transmitted by airborne dust. Louis Pasteur taught brewers to preserve the wort from the impurities and to heat the beer to 55°C to prevent disease.

Silkworm Diseases

In 1865, disease hit the silk industry and posed a threat to the economy of France and other silk-producing countries.

Louis Pasteur discovered that silkworms were affected by two diseases – silkworm nosema disease and flacherie. Under the microscope, he noticed that the worms with nosema disease developed shiny corpuscles, and showed that the disease was both hereditary and contagious.

He developed the cellular egg production method to enable the preservation of healthy silkworm eggs. He isolated the female moths to allow them to lay their eggs separately. After

laying, he ground the female moths and examined them under the microscope. If the shiny corpuscles were observed he destroyed the eggs, otherwise he kept them for breeding.

These simple processes saved the silk industry. But the research was of considerable value, paving the way for the study of contagious diseases. For the first time, problems of heredity and contagion were scientifically proven and prophylaxis rules were established.

Edward Jenner Invented Vaccination, Louis Pasteur Invented Vaccines

Between the ages of 55 and 65, Louis Pasteur developed microbiology, applying it to medicine and surgery. Having established that diseases were caused by microorganisms, he then sought to identify and find a means of fighting them. His finest accomplishment was rabies.

In 1877 he closely studied infectious diseases, discovering:

- **staphylococcus** as the cause of furuncles (boils) and osteomyelitis
- **streptococcus** as the microbe responsible for puerperal infection
- **pneumococcus**

Edward Jenner (1749-1823) had discovered that humans could be protected against smallpox by inoculating them with the vaccine, a disease generally seen in cattle and identical to smallpox, yet harmless in humans. Jenner's discovery was based on exceptional circumstances – the existence of a disease similar to the human disease, but in animals, with a causative agent that triggers a protective response in humans.

Based on this principle, Louis Pasteur used the infectious agents themselves to achieve immunization. The processes were then applied to numerous diseases such as cholera (1878) and anthrax (1881).

By applying his method to the study of infectious diseases (microbial agents), their prevention (asepsis), and their prophylaxis by immunization (vaccination), Louis Pasteur had founded the science of immunology.

Rabies and its Invisible Virus

In 1880, Louis Pasteur applied his experimental method to the study of a human disease. He chose rabies because it affected not only humans, but also animals on which he could experiment.

His initial efforts to isolate the rabies virus proved unsuccessful, as the virus remained invisible due to the poor resolution of the microscopes used. The virus was not seen until almost a century later, in 1962, with the advent of electron microscopy.

Because rabies is a disease of the nervous system, together with Emile Roux, he decided to inoculate part of a rabid dog's brain directly into another dog's brain. The inoculated dog subsequently died.

The experiment was then conducted on rabbits to reduce the risk to the scientists. After serial passage through several rabbits, the rabies incubation period was still six days. He had therefore produced a vaccine with stable virulence.

He then attempted to develop a vaccine with attenuated virulence. He suspended sections of spinal cord from rabid rabbits inside flasks to dry in a moisture-free atmosphere. Virulence gradually declined until finally disappearing. He injected these spinal cord sections into rabid dogs, followed by preparations of increasing virulence. They did not develop rabies. He then established a protocol to fight the disease effectively.

On February 25, 1884, together with Charles Chamberland and Emile Roux, Louis Pasteur announced the discovery to the French Academy of Science, which appointed a study commission to assess the method's efficacy. The method was deemed conclusive and approved.

Despite the satisfactory results with dogs, Louis Pasteur feared testing it on humans.

Overcoming Rabies

On the morning of July 6, 1885, Louis Pasteur was given the opportunity to overcome his fears and test his treatment on humans when Joseph Meister was brought to him. The nine-year-old boy from Alsace had been bitten by a rabid dog fourteen times.

Because he was not a physician, he requested that Dr. Grancher inoculate the child. In the space of 10 days, Joseph Meister received a total of 13 injections of rabid spinal cord that were progressively more virulent. This first vaccination was a success. Joseph Meister never developed rabies and became the first human to be vaccinated. However, Louis Pasteur kept his success quiet, as the experiment had been conducted in relative secrecy.

It was a different story the second time round. In September 1885, Jean-Baptiste Jupille, a 15-year-old shepherd, arrived at the laboratory. He had been severely bitten by a rabid dog. Louis Pasteur administered his treatment and was successful again. This time he vowed to tell the world his story.

Soon, vast numbers of people bitten by rabid animals came from all over France and abroad to the Ecole normale supérieure.

Louis Pasteur set up a rabies vaccination clinic, which also served as a research and teaching center.

Three years later the Institut Pasteur opened its doors.