

could be produced. The final proof of this experiment was dramatic. The Society of Agriculture of Melun had proposed to Pasteur a public trial of his new method. Twenty-five sheep were to be vaccinated and later inoculated with anthrax. Another twenty-five sheep unvaccinated, were inoculated at the same time. On April 28th and May 17th, 1881 the twenty-five sheep were vaccinated against anthrax and on May 31st the entire lot of sheep, fifty in all, were inoculated with anthrax. On June 2nd the results were recorded. Imagine the anxiety of Pasteur during these two days, but as he predicted the 25 vaccinated sheep remained well while the other died. He had convinced the skeptics and a new doctrine in the control of diseases was born.

From anthrax in sheep he turned to rabies in dogs and man. Although he did not succeed in isolating an organism for this disease, and no one since his time has succeeded, he did discover a successful method of preventable inoculation against the disease—the well-known Pasteur treatment. The technical difficulties on the study of rabies seemed at that date unsurmountable. After many failures Pasteur finally hit upon the idea of inoculating spinal cord substance of a rabied animal into the brain of a dog. This established a sure method of inoculation and a short incubation period. Then the problem of attenuating the virus arose and was solved by serial inoculation of rabbits and the dehydration of the cord. The results were that the virus could be attenuated to any desired degree and gradually increasing doses used.

In closing let me quote from an address by Stephen Paget. "To change the whole outlook of medicine and surgery Heaven took and trained a 'Pure Scientist'—who had never done an operation or written a prescription; a man who had to screw up courage even to look at some of the ordinary sights of a hospital—took this non-medical man of science and set him to be the head of all heads of the medical profession, to have them all obedient to his teachings and proud of the very sound of his beloved name."

II. LOUIS PASTEUR—THE MAN

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Louis Pasteur is being honored by scientific societies the world over as perhaps the greatest scientific genius of all times. He is rightly considered the master of his environment. To him is attributed the distinction of being the founder of bacteriology, the science, which permeates every phase of health and disease in plants and animals. The far reaching effects of his researches in

relieving suffering and saving life proclaim him one of the greatest benefactors of mankind.

Louis Pasteur was descended from a peasant family who had been tillers of the soil for centuries, but whose every ambition had been that their children might through thrift, industry and education rise above the conditions of their parents. He was born at Dole in the Department of Jura, France, on December 27, 1822; he died at Garches, a suburb of Paris on September 28, 1895.

Pasteur's father had been a soldier in the army of Napoleon and was decorated for valor in the field, but at the time of his son's birth he was following his trade as a tanner. Two years later the family moved to the little town of Arbois in the same department, and it was here that Louis Pasteur lived in close touch with nature, attended the primary school and later entered the College Communal and took classical studies.

As a student Pasteur showed no preference for any of his studies except drawing up to his thirteenth year. His crayon portraits of his mother, the mayor of Arbois, a nun, and some others had caused him to be considered an artist in his family circle. The fame of an artist, however, was not what his father desired for his son; his highest ambition was to see him secure in a position as a professor. So great was this desire that his family in spite of their poverty, decided to send him to a pension in Paris, to be prepared to enter the Ecole Normale.

Accordingly with a fellow student, he left his home circle and his beloved little town of Arbois in October 1838. On reaching Paris a melancholy seized him and his memories of his home at Arbois were so vivid that he could not adapt himself to his new surroundings and consequently he could not sleep and his languor and ill health made him unfit for work. He would say, "Oh! if I could only smell the odor of the tannery I should be well again."

The director of the Paris school fearing that the homesickness of his young pupil might injure his health notified Pasteur's father, who came and took his son home, where in the presence of the tannery and home environment he promptly recovered and continued his studies with zeal for another year in the College at Arbois. It is from the time of the Paris experience that Pasteur showed his incredible capacity for work and his great ambition to get ready to enter the Ecole Normale. From Besancon, where he attended college after Arbois, he wrote "When once we have acquired the habit of work we can no longer live without it. Besides work is the thing upon which everything else in this world

depends. By means of knowledge we raise ourselves above everybody else."

In 1843 he achieved his ambition of entering the Ecole Normale and devoted himself to his favorite study—chemistry, and three years later received his degree in the physical sciences. He greatly feared that he would be sent to some distant place where he could not carry on his researches. Fortunately this was not true. He became an assistant professor of Physical Science at the Ecole Normale and continued his researches in crystallography with keen vision. This work was carried on with tartrates and he found two forms of crystals present. He says: "I separated with care the right and left handed hemihedral crystals and observed separately their solutions in the polarization apparatus. Then with no less surprise than joy I saw that the right handed hemihedral crystals turned to the right and the left handed ones to the left, the plane of polarization, and when I took equal weights of each of these kinds of crystals the mixed solution was neutral to polarized light because of the neutralization of the two equal and opposite individual deviations." Furthermore he found that these hemihedral crystals rotated the polarized light the distance to the left that tartaric acid of the grape in equal concentrated solutions deviated it to the right.

In 1848 he was sent by the order of the Minister of Instruction to the Lycee at Dijon as Professor of Physics. As he had to abandon his experimental courses and his researches he asked to be transferred and in January 1849 he was appointed professor of chemistry at the University of Strasburg where he continued his researches in spite of scanty equipment.

On Pasteur's first visit to the president of the University of Strassburg, he became interested in one of his daughters and less than fifteen days after his arrival, he asked for her hand in marriage. This union proved to be a most happy one and till the end of his life Madame Pasteur surrounded him with tender and devoted care. He now prosecuted his researches with renewed energy and in 1853, he made racemic acid artificially. As a reward for this discovery the Society of Chemistry bestowed a prize of 1500 francs upon him. The Government had been following his achievements and gave him the Cross of the Legion of Honor when he was barely 30 years old.

In his studies with tartrates Pasteur noticed that they undergo fermentations and he believed this was due to a microscopic organism. This idea caused him to turn to a study of the origin of life.

When Pasteur began his studies on fermentation, a belief

that living organism could be produced from inanimate objects by spontaneous generation was firmly fixed by tradition. In fact Van Helmont in the sixteenth century had given a prescription for the creation of mice from grains of wheat, pieces of cheese and dirty linen. By carefully prepared experiments Pasteur proved that life begins from life, upsetting for all time the doctrine of spontaneous generation. He studied especially lactic acid and alcoholic fermentation and proved that each was due to the action of living cells. He furthermore gave definite proof that putrefaction and decay are the chemical by-products produced by the metabolic action of micro-organisms.

Pasteur's connection with the Industrial Institute at Lille had brought him in direct contact with the agricultural industries of France. In 1857 he was appointed Administrator of the Ecole Normale and director of the scientific studies. To return to Paris and continue his work on behalf of science and humanity was a happy event for Pasteur. Dr. Fleury says of him: "During 15 years he could be seen each evening after dinner pacing up and down along a corridor where no one dared to come and interrupt his reverie. Paralyzed since 1870—for on two different occasions apoplexy attacked his brain—as he walked he slightly dragged one foot while his mind ripened some newly conceived idea or prepared for the experiment of the morrow. At times his reverie assumed the intensity of ecstasy and within the brain of this man of genius flashes of light revealed his goal and gave him a prevision of all that was destined to emanate from him. 'How beautiful it is! How beautiful it is!' he would say and then he would add, 'I must work.'"

His first laboratory at the Ecole Normale consisted of two garret rooms fitted up by himself where the temperature went to zero in winter and 97°F. in summer. Certainly the great productivity of his primitive laboratory proves that here and elsewhere brick and stone do not make productive researches as is so often found in our own country where we have the buildings, equipment and everything except men who can and will make discoveries in science. From this primitive laboratory, Pasteur completed his studies on fermentation and differentiation of aerobic from anaerobic bacteria.

DuClaux said of his early researches: "Throughout the best years of his life this man lived in advance of his time, a pioneer lost in solitude, absorbed in the contemplation of the horizons he had discovered and which his eye alone could behold and traverse. He lived in his own thoughts without being a dreamer for a dream

which comes true ceases to be a dream."

His experiments showing that spontaneous generation is a myth, aroused great interest and people became anxious to look through the microscope to see micro-organisms. Napoleon III wished to meet him and was delighted with his serious and simple manner. He told the Emperor that his secret ambition was to study contagious diseases to find cures for all the ills of humanity.

The wine industry of France became nearly ruined by the souring of the wines. Pasteur was invited to occupy a laboratory placed at his disposal by his home town, Arbois, in 1864 to see if he could find the cause and cure of the acid that soured their "rosy and tawny wines." He replied to the mayor and town council, who had extended the invitation to him in a manner characteristic of the man, as follows: "This spontaneous offer from a town dear to me for so many reasons does too much honor to my modest labors, and the way in which it is made covers me with confusion." He feared that his services would not be in proportion to their generosity so he refused the offer and carried on his researches in an improvised laboratory in an old coffee room. He found that each disease of wine had its special micro-organisms and solved the situation by heating the wines to 135°F. and sealing them. This restored the industry which meant 500,000,000 francs annually to France alone.

For fifteen years a scourge had ravaged the silk worms of southern France and was proving fatal to the national silk industry with a loss of 120,000,000 francs annually. Pasteur was prevailed upon by the Minister of Agriculture and one of his former teachers, Dumas, to study pebrine, as the disease of the silk worm was called, to see if he could find a remedy. Although he knew nothing about silk worms he left Paris in 1865 and installed himself at a small silk farm near Alais. He became a cultivator of silk worms and after several years he found the organisms that were producing, not only the disease, pebrine, but also flacherie which was almost as fatal. He suggested remedies, which brought back the silk industry and wealth to the ruined sections of his country. But it was during this work (1868) that his left side became completely paralyzed and he was confined for six weeks before he could rise. When he was not expected to live, he said: "I regret to die: I should like to have been of more service to my country."

Pasteur was one of France's great patriots. When the Franco-Prussian war broke out in 1870-71, Pasteur due to his paralysis was not fit for military service and because of the siege of Paris he could not continue his work at his Paris laboratory, neither

could he get to Arbois to continue his study of silk worms, as the enemy had overrun his beloved town. So he went to the house of his pupil DuClaux. In March 1871 he wrote to DuClux: "I have my head filled with the finest projects for work but the war has forced my brain to lie hollow. I feel ready now to become productive again, although, alas I may be deceiving myself! How fortunate you are to be young and in good health! Oh! If I could only recommence a new life of study and toil! Poor France! Dear mother land!"

He now turned to a study of beer and soon he announced that all he diseases of beer came from micro-organisms and he showed that if bottled beer was heated to 122°F. it was unalterable. This discovery enabled France to cope with foreign competition.

Pasteur's next great discovery was with anthrax, by which the herds of cattle and sheep were greatly depleted in France. He took a drop of blood from an infected sheep and placed it in artificial media and after 10 succeeding inoculations he got a culture which produced anthrax in another animal. At the same time he was carrying on a similar research on chicken cholera and with this he discovered, that the germs became attenuated or lost their virulence, when grown on artificial media exposed to the air. These attenuated cholera bacilli when injected into fowls would cause a mild form of cholera which gave immunity to the fatal form of the disease.

He tried the same experiment with anthrax and found it effective, that is attenuated bacteria when injected caused a mild form of anthrax which made the animals immune. Pasteur announced his experiment on February 28th, 1881. Some received this with enthusiasm, others with distrust. On May 5th, the Society of Agriculture asked Pasteur to give a public demonstration. For this purpose 50 sheep and 10 cows were placed at his disposal. Twenty-five of the sheep were to be vaccinated with attenuated virus, and then to receive an inoculation, of virulent anthrax germs along with the twenty-five uninoculated sheep; of the ten cows six were vaccinated with attenuated virus and were then given virulent anthrax microbes along with the four unvaccinated ones. On May 31st, all of the animals were given the virulent anthrax virus. Every one of the unvaccinated animals contracted anthrax and died while not one of the vaccinated animals contracted the disease. This was a great triumph for Pasteur to make this demonstration before a large throng. Within a year after this demonstration 613,740 sheep and 83,946 cattle had been vaccinated against anthrax in France. By following his method the disease was prac-

tically eliminated from France and has been controlled over the rest of the civilized world ever since.

He next turned to a study of puerperal, or child bed fever, and discovered it is due to a microbe. He then authorized a course of cleanliness and precautionary measures for the doctors and midwives, which has saved the lives of millions of mothers.

In spite of the fact that the sight often made Pasteur ill, he and his students haunted the hospitals of Paris studying human diseases. One of his students, Roux, wrote: "How many times we have seen him hastily leave the amphitheatre of the hospitals because he was acutally ill! But his love of science, his curiosity to know the truth were even stronger; he always came back on the morrow."

Pasteur's crowning achievement was the cure of hydrophobia. It is well known that formerly mad dogs were the terror of the country side. All sorts of remedies had been proposed for those who had been bitten. Pliny the Elder, advised that victims eat the liver of the dog that had bitten them; Gallian prescribed eating eyes of crabs. In the middle ages oyster shell omelettes and cauterisation were prescribed; but a sure relief was the common practice of smothering the unhappy sufferers to death between two mattresses.

After a long series of experiments, Pasteur found he could not attenuate the organisms of hydrophobia on artificial media, as he was unable to isolate it. He then decided to attenuate it by passing it from rabbit to rabbit. In these experiments he discovered that the infected spinal cord lost in virulence in proportion to the time it was exposed to the air so that one that had been exposed for fifteen days was almost harmless, yet when a decoction of it was injected into dogs or other animals it gave them immunity to hydrophobia.

The news that Pasteur was able to produce immunity in animals spread widely. His first human patient was Joseph Meister, 9 years old, who had been bitten 14 times by a mad dog in Alsace and was in a lamentable condition. He was brought by his mother who begged Pasteur to treat her son. A vaccine from a dried rabbit cord 14 days old was made and injected into the boy's body. Subsequent doses of greater virulence were administered and no hydrophobia developed.

The second patient was J. B. Jupille, a boy 15 years of age, who had fought, bare handed and with no aid except his shepherd's stick, a mad dog and killed it to save his five shepherd comrades, but was terribly bitten and was in a worse condition than Meister and moreover a week had elapsed before he presented himself for treatment. The inoculations, however, were successful and he be-

came immune to hydrophobia. From this time hydrophobia victims flocked to Pasteur from all over the world.

A bronze statue representing the struggles of Jupille stands in front of the famous Pasteur institute in Paris.

This treatment, which has been in use practically unchanged from the way Pasteur announced it to the world, has reduced the mortality from hydrophobia to about one-half of one per cent.

Pasteur was devoted to his family, enjoying the closest sympathy and assistance of his wife and daughter in his great discoveries. He also had great respect for his father. In the dedication of one of his books to him, he said in part: "The longer I live the better do I understand the kindness of thy heart and the superiority of thy judgment." He took a kindly interest in his hydrophobia patients and wrote to them often giving them good advice after they had been discharged.

During his life Pasteur was guided by the purest and highest of ideals in science, virtue and charity. He was a deeply religious man. He once said: "The idea of God is a form of the idea of the Infinite. As long as the mystery of the Infinite weighs on human thought, temples will be erected for the worship of the Infinite, whether God is called Brahma, Allah, Jehovah or Jesus; and on the pavement of those temples men will be seen kneeling, prostrated, annihilated in the thought of the Infinite."

In 1892 an international jubilee was held in Paris to celebrate this man's 70th birthday. Lord Lister, the famous English surgeon, said at this meeting: "Truly, there does not exist in the entire world any individual to whom the medical sciences owe more than they do to you. Your researches on fermentation have thrown a powerful beam, which has lightened the baleful darkness of surgery, and has transformed the treatment of wounds from a matter of uncertain and too often disastrous empiricism into a scientific art of sure beneficence. Thanks to you, surgery has undergone a complete revolution, which has deprived it of its terrors and has extended almost without limit its efficacious power."

At the same meeting Tyndall said: "We have been scourged by invisible throngs, attacked from impenetratable ambuscades, and it is only today that the light of science is being let in upon the murderous domains of our foes." "The master mind of Pasteur has dominated the realm of bacteriology since 1860." "His epoch-making discoveries were largely due to his intuitive vision, his skill in device and in the adoption of means to ends, his prodigious industry, and the enthusiasm and love with which he inspired his associates."

At the dedication in 1888 of the Pasteur Institute, which was built by public subscription, Pasteur said: "Alas, it is my most poignant sorrow that I enter it as a man already vanquished with age, no longer surrounded by my masters"—to his collaborators he said: "Hold fast to the enthusiasm—which has been yours since the earliest hour,—assert nothing that cannot be proved in some simple and decisive fashion."

In concluding his dedicatory address he said: "Two adverse laws seem to me now in conflict. One law of blood and death, opening out each day new modes of destruction, forces nations to be always ready for the battle-field. The other a law of peace, of work, of safety, whose only study is to deliver man from the calamities which beset him.

The one seeks only violent conquests. The other only the relief of humanity. The one places a single life above all victories. The other sacrifices the lives of hundreds of thousands to the ambition of a single individual. The law of which we are the instruments, strives even through the carnage to cure the bloody wounds caused by the law of war. Treatment by our antiseptic methods may preserve thousands of soldiers.

Which of these two laws will prevail over the other? God only knows. But of this we may be sure, that science in obeying this law of humanity will always labor to enlarge the frontiers of life."

III. GREGOR MENDEL'S LIFE AND ACHIEVEMENTS

A. Richards

From the Zoological Laboratory of the University of Oklahoma.
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The contributions of Mendel to biological science have been recognized so generally during the last two decades that in many parts of the world during the past year scientific men have joined in celebration of the centennial of his birth. Bateson, one of the foremost students of heredity of the present day has made an extensive study of the life of Mendel and the events connected therewith. From his account*, many of the facts in the present

During the period from 1853 to 1868, Mendel was a teacher especially of physics in the Realschule at Bruenn, and during a certain part of this period he carried on experiments in the large garden of the cloister there. This institution which was the Aug-

*Mendel's Principles of Heredity: Biographical notice. University Press, Cambridge, 1913.
sketch are drawn.