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1822-1895
From the etching after Albert Edelfelt.

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JEAN JOSEPH PASTEUR, the father of the genius who made this name immortal, came of a working class family of old descent, once tillers of the soil, but for the two generations before his day, tanners in the south of France. Jean Joseph served in the Peninsular War in a regiment of the line distinguished for its fine record, and in it rose to the rank of Sergeant-Major and received the Cross of the Legion of Honour. Disheartened at the turn events had taken on Napoleon's defeat, he returned to his native town of Besançon and took up the trade of tanner. In 1815 he married Jeanne Etiennette Roqui, who like himself was descended from an old family whose lineage can be traced as far back as 1555, the Roquis being workers in the vineyards round the countryside. She is described as an active, imaginative woman, of a careful disposition and much absorbed in thought. Jean had not much education, for it was then considered sufficient if a man could read the Emperor's bulletins; but he appears to have been endowed by nature with a keen sense of values, for he strove all his life, amid the toils of a tannery, to improve himself in the things of the mind, and for his children, he coveted more than anything else a good education.

Louis Pasteur was born at Dôle on the 27th of December 1822. After the birth of two daughters, the family moved and finally settled in the small town of Arbois, where a better tannery offered a surer means of livelihood, and Louis attended classes at Arbois College. At school he was not considered more than a good average pupil, hard-working and very quiet, but the headmaster was attracted by qualities in him which he thought worthy of encouragement. The boy's reluctance to commit himself to making any statement before he was convinced of its truth, his industry, his caution, combined with a lively imagination, seemed to the master, if others put them down to a slow wit, to be habits of mind which should be cultivated, and, at his suggestion, Louis was sent to Paris to prepare for the entrance to the *École Normale*, a school founded in 1808 by Napoleon I. for the training of teachers. But Paris was far from Arbois, and Louis, a reserved, sensitive boy of fifteen, taken from a family who were warmly attached to one another, was overcome with homesickness. He felt that only a "whiff of the tannery yard" could cure him, and, although he fought valiantly against this nostalgia, it became evident to his masters that he was falling into low spirits, and eventually he was sent home. He got a place in Besançon College as a pupil teacher, and in 1842 sat for the entrance for the *École Normale.* Although he passed the examination, the place he took was too low to satisfy him, and he decided to try again in the following year. It is interesting to note that in chemistry, the examiners classed him as "mediocre." In October 1842, he went to Paris for the second time, taught at the Barbet Boarding School for a modest salary, while he attended the lectures of the celebrated chemist M. Dumas, at the *Sorbonne.* In

a year's time he was admitted fourth on the list to the *École Normale.*

The first discovery made by Pasteur, the discovery of the molecular dissymmetry of tartaric acid, attracted the attention of the scientific world. Tartaric acid was first discovered in the thick crust which forms in wine barrels, by a Swedish chemist in 1770, and another form of it, by some named paratartaric acid, by others racemic acid, was accidentally obtained by Kestner, an Alsatian manufacturer, whilst he was preparing some tartaric acid in his factory at Thann in 1820. Kestner was unable to reproduce the racemic acid, and, although many chemists came to Thann to study this mysterious substance, the problem of its composition remained unsolved. Kestner had, however, kept a stock of what he had accidentally prepared. Pasteur had been studying the tartars for some time, when M. Biot, the famous French chemist, then an old man, communicated a paper by the German chemist Mitscherlich, to the *Académie des Sciences*, in which Mitscherlich gave an account of his work on the tartars and described his discovery that while a solution of tartaric acid, when tested in the polariscope, deflected the plane of a ray of polarised light, a solution of racemic acid, a substance of crystalline form similar to tartaric acid, had no action upon the ray of light. It was neutral. Why should the one solution, of like composition with the other, rotate the plane of light and the other not? To this problem Pasteur supplied the answer. Examining the tartaric acid crystals through his microscope, he discovered on their edges little faces, which neither Mitscherlich nor that expert in physics, de la

Provostaye, whose work Pasteur had just been studying, had observed. And from the position of these faces which inclined to the right, he concluded that the crystals must be what is called dissymmetric, *i.e.*, one of a pair, and that somewhere the corresponding crystal, with its face inclined to the left, must exist. He looked for this left-handed crystal in racemic acid, but he found that this acid contained both crystals, those with faces inclining to the right and those with faces inclining to the left. Very carefully he picked out the crystals, separating the right-handed from the left. Placing each of these separately in the polariscope, he found that they deflected the plane of light, the one to the right hand, the other to the left. Then mixing an equal number of right-handed and left-handed crystals, he placed them together in the polariscope and found that they had no action on the ray of polarised light, for they neutralised each other. It was clear, then, that racemic acid was composed of equal quantities of right and left-handed crystals, and the problem of the optical inactivity of this substance which had confounded the great chemist Mitscherlich, was solved. In his excitement, his biographer tells us, Pasteur rushed out of the laboratory and seizing the first man he met, took him to the Luxembourg Gardens to tell the story.

Pasteur was twenty-six when this discovery was made. His joy in it was overcast by the sudden death of his mother, to whom, as to all the members of his family, he was very devoted. But it drew upon the young man the eyes of the scientific world of Paris. The old chemist Biot, always sceptical of any new discovery, summoned him with his crystals to perform the experiment before him, and when he

was convinced of its truth he became, and remained for the rest of his life, one of Pasteur's most ardent adherents. At a later date, Biot arranged a meeting with Mitscherlich, at which Pasteur gave a demonstration of his work, and was introduced to many illustrious members of the *Académie des Sciences.* He was not content, however, with having explained the relation between optical activity and the crystalline forms of the tartars, but wished to produce racemic acid artificially. The difficulty of finding this very rare substance in its crude state retarded his experimental work, and when he heard from Mitscherlich's friends that racemic acid could be obtained at the works of a manufacturer in Leipzig, he could not rest till he made the journey in search of the treasure. In 1849, after having been appointed Professor of Physics at Dijon, a post which interrupted his researches in Paris and removed him from the society of many distinguished colleagues, he was appointed to the Chair of Chemistry at Strasbourg. Here he married Marie, the daughter of M. Laurent, Rector of the Academy of Strasbourg, a wife who shared his enthusiasm for science, his anxieties and his hopes, and who devoted her life to his welfare. To her, writing from Leipzig, where his search for racemic acid had begun, he said: "I have not left the laboratory for three days, and I know nothing of Leipzig but the street which goes from the *Hotel de Bavière* to the University." But the racemic acid in Leipzig was not sufficiently crude for his purposes, and he continued his search in Freiburg and many other towns, until at last in Vienna, he found the raw article. Pasteur had spent five years on his researches on the tartars. It was his habit not to proclaim his results till he could support them with the most rigid proofs. "I am bound to eliminate every cause of error," he said, "every perturbing influence; I can maintain my results only by means of the most irreproachable experiments." He announced his success in obtaining racemic acid artificially in 1853. A telegram to M. Biot in Paris bore the cryptic announcement: "I transform tartaric acid into racemic acid"; but writing to his father, whom he always kept informed of his work, he said: "Here is at last that racemic acid (which I went to seek at Vienna) artificially obtained through tartaric acid. This discovery will have incalculable consequences." For this he was awarded the red ribbon of the Legion of Honour, and received a prize of 1500 francs from the Pharmaceutical Society, half of which sum he devoted to the equipment of his laboratory in Strasbourg.

In 1854 Pasteur was made Professor and Dean of the Faculty of Science at Lille. Here in the centre of an industrial town in a country of distilleries, the opportunities for research on the subject of fermentation, that now obsessed him, were manifold. "In the fields of observation," he said to his pupils, "chance only favours the mind which is prepared," and the record of his life is one long illustration of this remark, for the problem had only to be set for this man of genius to find the answer. When in 1856 complaints were made in Lille of failures in the manufacture of alcohol from beetroot, Pasteur went down to the factory himself daily to study these failures, returning laden with fermentation juices which he examined under a microscope in his laboratory. The origin of life, that much discussed subject, centuries old, was what interested him now. Were bacteria

produced without parents, arising from some disturbances in putrefying matter itself? The whole subject was at this time very obscure, but the doctrine of spontaneous generation for the most part held the day. It was the orthodox belief and was defended with all the zeal and bigotry that the orthodox of every age bring to bear on the authors of any new doctrine. In the seventeenth century micro-organisms had been discovered, and experiments with gauze-protected meat had, in fact, disproved the theory of spontaneous generation; but these experiments were not followed up to their logical conclusions, and their application to the facts of everyday life was overlooked. Studying the souring process in milk, Pasteur observed under the microscope some tiny globules floating about in a grey substance. Separating the grey matter, he put some of it in a liquid suitable for its growth, and watched for the result. It grew and produced a ferment, for he had indeed isolated the living germ which, acting upon milk, causes fermentation. In 1857, after exhaustive researches, he presented to the Lille Science Society his paper on lactic fermentation, and three months later read it to the *Académie des Sciences* in Paris. This paper was the foundation of the new science of bacteriology, so familiar to us to-day, but at that date calculated so to upset men's current notions, that the controversy it set going lasted in some degree to the end of Pasteur's life.

In the same year Pasteur received the appointment of Administrator and Director of Scientific Studies in the *École Normale* in Paris. Biot, his old master, protested against this appointment, thinking the authorities were wasting his fine talents in routine duties: "They have made of him an administrator," he said, "let them believe that he will administrate." But Pasteur, the most conscientious of men, fulfilled all his duties with scrupulous care, while he worked unceasingly in the garret in the Rue d'Ulm, which was all that was afforded him for a laboratory, on the subject of alcoholic fermentation, and in December 1857 he presented a paper to the *Académie des Sciences*, showing that "the deduplication of sugar into alcohol and carbonic acid is correlative to a phenomenon of life, an organisation of globules."

In 1860 the *Académie des Sciences* awarded him the prize for Experimental Physiology, and in awarding it, Claude Bernard, the famous physiologist, alluded to "the great physiological interest" of the results of Pasteur's experiments on alcoholic fermentation, lactic fermentation, and the fermentation of tartaric acid, with their inevitable reaction on the profession of medicine. Pasteur himself, writing to an old school friend at this time, said: "I am pursuing as best I can these studies on fermentation which are of great interest, connected as they are with the impenetrable mystery of Life and Death. I am hoping to mark a decisive step very soon by solving, without the least confusion, the celebrated question of spontaneous generation. . . . There is so much obscurity, together with so much passion, on both sides, that I shall require the accuracy of an arithmetical problem to convince my opponents by my conclusions." And, writing to his father, he spoke of "the future reserved to those great results, so unexpected, and opening such an entirely new outlook to physiology."

In 1862 he was elected a member of the *Académie des Sciences* by 36 votes out of 60. Pouchet, the Director

of the Natural History Museum of Rouen, was one of Pasteur's chief opponents, and he declared that he was prepared to demonstrate that "animals and plants could be generated in a medium absolutely free from atmospheric air, to which no germ of organic bodies could possibly have been brought by air." Pasteur, on the contrary, maintained, and had proved experimentally, that any easily corrupted liquid, such as yeast water, could be kept pure indefinitely when enclosed in a flask, brought to boiling point in order to kill any germs already in it, and sealed. Moreover, he proved that the same liquid could still be preserved in a pure state by keeping it in an unsealed bottle with a curved neck, because the air which then reached it had deposited its germ-laden dusts on the curved neck of the bottle. He demonstrated this at a public lecture given in the Sorbonne in 1864, when all Paris was present, the fashionable and literary worlds now being interested in this momentous question of spontaneous generation, which was causing such an upheaval in the world of science. Holding up his two flasks of liquid, the one straight-necked, the other curved, Pasteur addressed his spell-bound audience: "Why does one decay and the other remain pure?" he asked. "Because in the first case the dusts suspended in the air and their germs can fall into the neck of the flask and come in contact with the liquid and develop; thence microscopic beings. In the second flask it is impossible, or at least extremely difficult, that dusts suspended in the air should enter the vase; they fall on its curved neck . . . everything in the air save its dusts can easily enter the vase. . . . And, therefore, gentlemen, I can point to that liquid and say to you, I have taken my drop of water from the immensity of creation, and I have taken it full of the elements appropriated to the development of inferior beings. And I wait, I watch, I question it, begging it to recommence for me the beautiful spectacle of the first creation. But it is dumb, dumb since these experiments were begun several years ago; it is dumb because I have kept it from the only thing man cannot produce, from the germs which float in the air, from Life, for Life is a germ and a germ is Life."

For the next six years that other great genius, Lister, was working out with such success in Glasgow and in Edinburgh his method of antiseptic surgery, founded on Pasteur's germ theory; yet in 1870, when the war between France and Germany broke out, Lister's methods were not generally applied to the wounds of the French soldiers, and the dust-laden air brought in its train as of old, septicæmia, erysipelas and gangrene, which carried off in their thousands the young men of France.

In the years 1865 and 1866 Pasteur lost two daughters from typhoid fever and his father died at Arbois. At this time the Ministry of Agriculture sent him to Alais, a centre of the silk-worm industry, to study the silk-worm disease which for twenty years had been ruining the trade. Pasteur's protest of his unfitness for this task, in that he had never seen a silk-worm, was disregarded by the Minister, whose action was amply justified by the result. The silk-worm or corpuscle disease was called *pebrine* from the resemblance of the spots with which the worms were covered to specks of pepper, and the silk-manufacturers had exhausted every conceivable method of obviating the infection by disinfection, fumigation, by using

only guaranteed pure seed in breeding the worms, but all in vain. Ruin stared them in the face. After numerous experiments on the seed, both guaranteed and unguaranteed, Pasteur concluded that the disease developed chiefly at the chrysalid and moth stage, according as the seed itself had been slightly or heavily infected. Its existence had therefore been overlooked in the guaranteed seed, in which it remained dormant until the moth stage was reached. In order that they might discover earlier the existence of the symptoms, Pasteur taught the manufacturers to hasten the development of the moths by raising the temperature in which they were hatched. They were then examined through the microscope and destroyed if unhealthy. "The sickly character is then so easy to detect," he said, "that a woman or child can do it. If the cultivator should be a peasant without the material required for this study, instead of throwing away the moths after they have laid their eggs, he can bottle a good many of them in brandy and send them to a testing office or to some experienced person, who will determine the value of the seed for the following year." "The corpuscle disease," said Pasteur, "is as easily avoided as it is contracted." All countries interested in the manufacture of silk benefited by his recommendations, and Italy especially carried out his methods with great success.

By his studies on wine, he saved his own country millions of francs, showing the manufacturers how, by heating the wine, the diseased parasites could be killed, and the wine itself improved rather than deteriorated in the process; and he showed the vinegar makers how they could increase the speed at which vinegar fermented, making of a long process, a short one. Napoleon and the Empress Eugenie inquired of Pasteur why he had not turned these researches into a source of profit for himself. His reply was characteristic of his attitude to life: "A man of science would complicate his life, the order of his thoughts, and risk paralysing his inventive faculties," he said, "if he were to make money by his discoveries."

In May 1867, he received the Grand Prize Medal for his work on wine. It was conferred by the Emperor himself in the *Palais de l'Industrie* amid a brilliant assembly.

After returning from Alais, Pasteur, at the age of forty-six was struck down by a cerebral hæmorrhage from which he very nearly died, and which left him with a slight paralysis on the left side. His recovery was slow, and before it was complete, the Franco-Prussian War broke out. With difficulty he was persuaded to go to Arbois, and there from a sick-bed he carried on with the efficient help of his family such researches as he could. The war, however, nearly broke his heart. He returned the honours he had received from Germany in recognition of his scientific work, and refused, even many years afterwards, to accept any honorary degree from that country. And in order that France should not occupy an inferior place to Germany in the manufacture of beer, he studied the brewing industry for the five years that followed the war, and published in 1876 his *Études sur la Bière*.

In 1873 he was elected an Associate of the *Académie de Médecine* by a majority of only one vote. He thus obtained the opportunity he had long desired of bringing home to the medical world within its own domain the application of his discoveries to

the profession. This man, a chemist, not a physician, interrupted the medical discussions to point out to an amazed and incredulous assembly the micro-organisms they would find in the diseased bones of children; and when they laughed at him for his statement that a microbe, and a microbe alone, was responsible for the infection of puerperal fever in childbirth, he drew on the blackboard an exact representation of the microbe to be found in the blood of a patient suffering from this disease, saying to his astonished hearers, "Tenez, voici sa figure." When he read his celebrated lecture on the Germ Theory in 1878, addressing the surgeons, he said: "If I had the honour of being a surgeon, convinced as I am of the dangers caused by the germs of microbes scattered on the surface of every object, particularly in the hospitals, not only would I use absolutely clean instruments, but, after cleansing my hands with the greatest care and putting them quickly through a flame, I would use only lint, bandages and sponges which had previously been raised to a heat of 130° c. to 150° c.; I would only employ water which had been heated to a temperature of 110° c. to 120° c." The *Académie de Médecine*, accustomed to long and weighty discourses upon the theory of disease, became inured to some practical demonstrations before Pasteur's day was done. He once had occasion to bring to the *Académie* a cage of fowls to demonstrate the fact that, although a hen is proof against the germ of anthrax because the temperature of its blood, being higher than that of mammals, does not favour the growth of the germ, yet it will contract the disease if its temperature is artificially lowered by means of a cold bath; and, more than that, it will recover again if removed from the bath and warmed before the disease is too far advanced. This experiment was carried out before the august assembly because one of its members had defied him to produce anthrax in a hen, and Pasteur, no doubt, had a twinkle in his eye as he immersed the hen in the cold water on so grave an occasion.

When he had discovered a protective vaccine against anthrax, after a series of brilliant researches, he was provided by the agriculturalists with sixty sheep for practical demonstration. Twenty-five of these he vaccinated with his protective vaccine, twenty-five he left unvaccinated and therefore unprotected, and ten he kept for comparative purposes. He then administered a dose of the anthrax germ to the fifty sheep. A vast multitude of farmers, veterinary surgeons and doctors came to the farm at Pouilly le Fort to witness this experiment, and the fame of it was spread over Europe, for anthrax was a disease very prevalent on the Continent. "The twenty-five unvaccinated sheep will all perish," said Pasteur, "the twenty-five vaccinated ones will survive." And, as he had said, so it was, and the twenty-five survivors compared favourably with the ten which had been untreated.

In 1880 he took up the study of chicken-cholera and in the course of this research, made a discovery which, in its eventual application, altered the whole course of clinical treatment in medicine. We are quite familiar to-day with the small glass bottles of cultures of gradually increasing degrees of strength sent out from the laboratories, which give us immunity, with no ill effects, from so many diseases; but before Pasteur turned his attention to chicken-cholera, the virulence of his prepared cultures had been of one

strength. His chief concern had been to find a suitable medium in which to cultivate his germs. A lucky accident drew his attention to a means of procuring attenuated doses. He was inoculating some hens with a culture which had been overlooked and laid aside for a few weeks unused, and while waiting for his hens to die, as they did when inoculated with a new culture, he was surprised to find that, although they became ill, they recovered. Subsequent researches showed that the action of oxygen on the culture that had been laid aside had reduced its strength, and thus the way was shown to a means of producing an attentuated culture of any desired strength by allowing a longer and longer interval to elapse before the cultures were used. He could then inoculate his animals with a mild dose, increasing it gradually until they became able to resist even a dose of virulent microbes at full strength. Conversely, he discovered by his studies on anthrax in 1881 that he could increase the strength of the micro-organism by passing it through a succession of guinea-pigs, whose blood supplied a suitable medium for its growth, until he got it up to full virulence.

For this discovery Pasteur was awarded the Grand Cross of the Legion of Honour, and in 1882 he was elected a member of the *Académie Française*, that eminent body composed of forty of France's most honoured sons. This recognition of his work gave him intense pleasure. "I had never in my life," he said, "contemplated the great honour of entering the *Académie Française*—an invitation so glorious for Science and so flattering to myself."

The last years of his life were given up to a long series of researches on hydrophobia, that most terrible scourge, for which no remedy then existed. After an exhaustive and inconclusive search for the microbe of rabies in the saliva of animals afflicted with this disease, he sought and found it in the spinal cord and the brain. By taking his virus from the spinal cord of a dog infected with rabies, and drying it in a phial of dried air until its virulence was reduced, he produced his attenuated dose and could then inoculate a healthy dog with doses increasing in strength until the animal became immune from any ill effect even from the bite of the most rabid beast. In 1885 he made his first human experiment on Joseph Meister, a child of nine, who was brought to the laboratory terribly bitten by a mad dog. The experiment was entirely successful, but cost Pasteur intense anxiety until the period of incubation was over. Thereafter the stream of patients arriving at the Paris laboratory became so large that special arrangements had to be made to treat them. Eventually every country subscribed to the establishment of the Pasteur Institute.

The long strain and anxiety of the work on hydrophobia had told upon Pasteur's health, and in the winter of 1886 he was persuaded to take a holiday in Bordighera, but in spite of the sunshine and brightness of the climate, he was not happy there. Reports of the inevitable opposition aroused by his discoveries disturbed him, and he longed to return to his laboratory, where he could refute his adversaries by practical demonstration. From Bordighera he went to Arbois and, amid the associations of his early days, his health and spirits revived for a time, and he returned to Paris in July 1887. He was appointed Life-Secretary of the *Académie des Sciences*, but in 1888 another shock of paralysis obliged him to resign

from this post. He rallied once again, however, and spent much of his time inspecting the arrangements for the Pasteur Institute or among the patients in its laboratory, but his health was gradually failing. In 1894 he left Arbois after his holiday for the last time and returned to Paris, to watch from his study window all the coming and going and activity in the new Institute, proud that his disciples and collaborators should have such magnificent facilities for their work which was founded on his own labours in the small laboratory in the Rue d'Ulm.

On the 28th of September 1895 he died peacefully at Villeneuve L'Etang, not far from Paris, where his work on hydrophobia had been chiefly carried out. There is a chapel erected to his memory at the Pasteur Institute, but his enduring memorial is all around us everywhere in the common life of every day; in the preservation of our food, the fertilising of our soils, the sanitation of our cities and in the work of every laboratory and hospital in the world. For his discoveries were the foundation of an unceasing train of researches of incalculable benefit to the human race.

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