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PASTEUR
SCIENCE AND MEDICINE

BY

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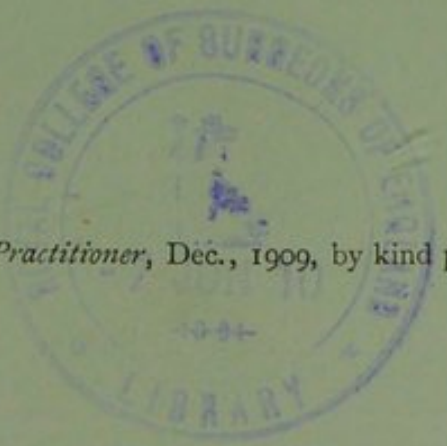
An Address delivered at Gresham College



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16. Pasteur, Science, and Medicine. By F. M. Sandwith, M.D., F.R.C.P.
17. The Helpfulness of Physiological Experiments to the General Practitioner. By James Mackenzie, M.D. (*In the press.*)
18. Correspondence in *The Times*, Jan., 1909.
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RESEARCH DEFENCE SOCIETY.

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Issued by The Research Defence Society.

PASTEUR, SCIENCE AND MEDICINE[1]

By F. M. SANDWITH, M.D., F.R.C.P.,

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Louis Pasteur was born at Dôle, in France, in 1822. His father was a man of little education, but of great natural industry and intelligence; he was "drawn" as a conscript in 1811, went through the Peninsular campaign in the 3rd Regiment, which was called "brave amongst the brave," and was decorated with the Cross of the Legion of Honour by Napoleon I. Soon after his return from the wars he married Jeanne Roqui, and the young couple settled at Dôle. Louis was their third child. Some sixty years later a memorial plate was placed on the house to commemorate the birth of Louis Pasteur, of whom Dôle had then become justifiably proud. The Director of Fine Arts of France, representing the Government on the occasion, pronounced these words:—

"In the name of the Government of the Republic, I salute the inscription which commemorates the fact that in this little house, in this little street, was born, on December 27, 1822, he who was to become one of the greatest scientists of this century, so great in science, and who has, by his admirable labours, increased the

[1] An Address delivered at Gresham College.

glory of France and deserved well of the whole of humanity."

To which Louis Pasteur answered :—" I am profoundly moved by the honour done to me by the town of Dôle ; but allow me, while expressing my gratitude, to protest against this excess of praise. By according to me a homage rendered usually but to the illustrious dead, you anticipate too much the judgment of posterity. But after protesting against the brilliant testimony of an admiration which is more than I deserve, let me tell you that I am touched, moved to the bottom of my soul. Your sympathy has joined on that memorial plate the two great things which have been the passion and the delight of my life : the love of science and the cult of the home. My father and my mother, dear departed ones, who lived so humbly in this little house, it is to you that I owe everything. Your enthusiasm, my brave hearted mother, you have instilled into me. If I have always associated the greatness of science with the greatness of France, it is because I was impregnated with the feeling which you had inspired. And you, dearest father, whose life was as hard as your hard trade, you have shown me what patience and constant effort can accomplish. It is to you that I owe perseverance in daily work. Not only had you the qualities which go to make a useful life, but also admiration for great men and great things. To look upwards, learn to the utmost, to seek to rise ever higher, such was your teaching. I can see you now, after a hard day's work, reading some story of the battles in the glorious days of which you had been a witness. Whilst teaching me to read, your care was that I should learn the greatness of France."

Soon after the birth of Louis the family settled at

Arbois, where the boy was sent to school. There is no evidence of his having shown any precocious cleverness. Like many other men distinguished later in life, his mind developed slowly, and during his school days he was only considered a good, average scholar, industrious, and very conscientious, with a marked talent for drawing. He was fortunate in his parents. From the first his best friend was his father, whose intense interest in his children's education must have been the most effective stimulant to their enthusiasm. Hampered by very narrow means and his own lack of education, the father was determined to make every sacrifice to give to his children the best teaching procurable, and the home life was ennobled by this spirit of sacrifice, and by the high ideals and patriotism of both parents.

Years later, when Pasteur was working in Paris, his father, still anxious to master his own lack of learning, entered into a teaching correspondence with him, the son setting the lessons, the father sitting up late at night to prepare the answers to be sent to his boy in Paris.

The son was fortunate also in the friends whom the Pasteurs gathered round them, and owing to their influence Louis was sent, at the age of 15, to a school in Paris. But this proved to be too hard a trial to the home-loving, sensitive boy, who fretted so persistently that his father brought him home a few months later. For a time he appeared to be satisfied with the narrow life of the little provincial town and gave up most of his time to his artistic work, but his feverish desire for study soon overcame his reluctance to leave home, and he entered the College of Besançon, 25 miles away. Here he was advanced to the post of assistant master and worked with unflagging zeal to prepare himself

for the final examination. He did not succeed in passing this with any distinction, and therefore determined to return to Paris to try again.

His industry was tremendous. To try to relieve his parents of some of the expense of his education he gave lessons to younger students whilst he continued his own studies, visited libraries and attended lectures. Amongst others he listened to those of Dumas, a celebrated chemist, who was the first to fill him with enthusiasm for this subject, of which he was to become so great an exponent. He passed his examinations successfully and entered the École Normale, continuing to teach others while he was being taught. This love of work for the sake of work is shown in his early days and continued all through his laborious and noble life. If genius consists in an infinite capacity for taking pains, there was never a greater genius than Pasteur. He was always most modest of his own achievements, but full of fiery enthusiasm for the work of others.

Speaking many years later to some students at Arbois of the success he had attained in his researches, he attributed it to "assiduous work, with no special gift but that of perseverance joined to an attraction towards all that is great and good." This was the keynote of his life, an intense love of work and a passionate desire to help the world forward.

It was in his student days, at the age of 22, that his attention was first attracted to certain acids, tartaric acid and paratartaric acid, which were puzzling the analytical chemists of the day. Pasteur could not then give sufficient time to the problem, but certain flashes of insight which might solve the problem had come to him, and he was determined to return to the subject as soon as possible. He passed his Physical Science

competition, and was taken into the laboratory of Balard, a lecturer at the school, who had the insight to recognise in the retiring and studious pupil the signs of a great scientist of the future. Pasteur now devoted much time to working at crystals, and writing of this time he says :—" I began to study carefully the formations of a very fine series of combinations, all very easily crystallised, tartaric acid and the tartrates." These researches, worked out under great difficulties, in opposition to previous theories, solved some problems which had long been discussed in the scientific world, and their solution caused great sensation among those who understood their value. He always had the power of proving his theories till they became facts and could not be denied, and he was never satisfied with his own work till he could thus prove it.

This work on crystals was his first contribution to science, and brought him infinite joy.

We next find him, in 1848, as Professor of Physics at Dijon, where he took up his work with his accustomed thoroughness, although it was a bitter disappointment to him to renounce temporarily his laboratory work.

The well-equipped laboratories of the present day are rendered perfect with every facility that light, air, water and instruments can give, but it was very different in France in those early days of Pasteur's work, when the greatest scientists had to study in cellars or in attics with no aids of any kind, and often had to labour at the expense of their health. Yet to Pasteur work in such a hovel was the acme of happiness.

Fortunately he was not long condemned to teaching work only ; his friends in Paris persuaded the authorities to give him a post where he could carry on scientific investigations, and, in 1849, he was appointed Assistant

Professor of Chemistry at Strasburg, then, of course, a French town. Here he married Marie Laurent and lived a happy, hard-working life for five years. His teaching, as well as his writing, became celebrated for the manner in which he made the most difficult subject clear and interesting. Biot, the great scientist, said of him, "He throws light upon everything he touches." In 1853 the red ribbon of the Legion of Honour was given to him for his scientific work; and, with 1,500 francs given him as a prize by the Pharmaceutical Society, he was able to buy instruments which the Strasburg laboratory was too poor to procure.

In 1854 he was made Professor and Dean of the Science Faculty at Lille University, and here he was able to carry out a plan he had long cherished, of bringing industry and science into closer touch, of putting his laboratory at the disposal of young men preparing for an industrial career, and teaching them the elements of science as applied to local industries.

"Where will you find," he said, "a young man whose curiosity and interest will not immediately be awakened when you put into his hands a potato, when with that potato he may produce sugar, with that sugar alcohol, with that alcohol, ether and vinegar? Where is he that will not be happy to tell his family in the evening that he has just been working out an electric telegraph? Be sure such studies are seldom, if ever, forgotten. It is somewhat as if geography were taught by travelling; such geography is remembered because one has seen the places. In the same way your sons will not forget what the air we breathe contains when they have once analysed it, when in their hands and under their eyes the properties of its elements have been resolved. Without theory, practice is but routine born

of habit. Theory alone can bring forth and develop the spirit of invention. It is for you not to share the narrow opinion which disdains everything in science which has not an immediate application. You know Franklin's charming saying. He was witnessing the first demonstration of a purely scientific discovery, and people around him said : 'But what is the use of it?' Franklin answered them : 'What is the use of a new born child?' Yes, gentlemen, what is the use of a new born child? And yet, at that tender age, germs perhaps exist in it of great talent. In your baby boys, fragile beings as they are, there are incipient magistrates, scientists, heroes as valiant as those who are now distinguishing themselves under the walls of Sebastopol. And thus, gentlemen, a theoretical discovery has but the merits of its existence ; it awakens hope, and that is all. But let it be cultivated, let it grow, and you will see what it will become. Do you know when it first saw the light, this electric telegraph, one of the most marvellous applications of modern science? It was in that memorable year, 1822: Oersted, a Danish physicist, held in his hands a piece of copper wire, joined by its extremities to the two poles of a Volta pile. On his table was a magnetised needle on its pivot, and he suddenly saw the needle move and take up a position quite different to the one assigned to it by terrestrial magnetism. A wire carrying an electric current deviates a magnetised needle from its position. That was the birth of the modern telegraph. Franklin's interlocutor might well have said when the needle moved, 'But what is the use of that?' and yet that discovery was barely twenty years old when it produced by its application the almost supernatural result of the electric telegraph."

Pasteur's lectures attracted large audiences and became

celebrated throughout the world, while his devotion to his teaching work was such that he would sacrifice days from his studies in the laboratory—and this was the greatest sacrifice to him—to take his pupils round factories and foundries in the neighbourhood. Speaking to an audience of medical students in Edinburgh in 1884, he said: "Ever since I can remember my life as a man, I do not think I have ever spoken for the first time to a student without saying to him, 'Work perseveringly; work can be made into a pleasure and alone is profitable to man, to his city, to his country.' Whatever career you may embrace, look up to an exalted goal; worship great men and great things. Great things! You have indeed seen them. In no country is the memory of great men better honoured than in yours. But if work should be the very life of your life, if the cult of great men and great things should be associated with your every thought, that is still not enough. Try to bring into everything you undertake the spirit of scientific method. You especially, medical students of this celebrated University of Edinburgh, be you inspired by the experimental method. To its principles Scotland owes such men as Brewster, Thomson, and Lister."

Other work was now in store for him. In 1856 some manufacturers of Lille had been disappointed in the failure of their alcohol made from beetroot, and Pasteur was consulted. He had already shown great interest in the study of ferments, and now he threw himself with the deepest interest into this new research. After months of patient investigation he propounded new theories on fermentation which revolutionised chemistry and became, after years of opposition and strife, doctrines which cannot be refuted.

Fermentation had been spoken of as a "mystery," an "influence," but Pasteur recognised in it a phenomenon of life and of reproduction. He read a paper on lactic fermentation before the Lille Scientific Society, bringing to light many newly discovered facts. That same year, 1857, he was appointed Administrator at the École Normale, his old school in Paris, and with his usual energy he set himself the task of administering every detail with thoroughness and sympathetic care. As a laboratory he had but a miserable garret, but his courage never failed him; if the difficulties were great his perseverance was greater. He continued his work on ferments and read an epoch-making paper on alcoholic fermentation. Great problems were occupying his mind, but he would publish no theory till he had proofs. "In experimental science," he said, "it is always a mistake not to doubt when facts do not compel you to affirm."

In 1859 he lost his eldest child, and two other children died in the years that followed. It was a bitterness he never recovered from, for his love of children was always great, and he was deeply attached to his own.

In 1860 the Academy of Science conferred on him the prize for Experimental Physiology. At this time Pasteur wrote:—

"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. Already I could speak, but I want to push my experiments yet further. 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 of my conclusions. I intend to attain even that. God grant that by my persevering labours I may bring a little stone to the frail and ill-assured edifice of our knowledge of those deep mysteries of life and death, where all our intellects have so lamentably failed."

It is difficult now for us to realise the storm of opposition raised by the theories Pasteur had propounded, theories in these days so firmly established that it never occurs to any of us to doubt them. But in 1860 many of the distinguished men of the day still believed that spontaneous generation took place continually. Pasteur now undertook to prove the contrary.

To do so, he drew a current of apparently pure air through a tube containing a little cottonwool, and found that the wool, acting as a filter, had particles of dust deposited upon it, and that this dust contained organic spores and germs. "There are therefore," he argued, "some organised corpuscles in the air. Are they germs capable of vegetable production or of infusion? That is the question to solve." He made a series of experiments to prove that the most sensitive liquid, such a milk, if placed where no dust could reach it, remained pure an indefinite time. "Gases, fluids, electricity magnetism, ozone, things known or things occult, there is *nothing* in the air that is conditional to life, except the germs that it carries," he concluded. His next experiments were to prove that the air on high mountains, beyond the reach of animal and vegetable decay, was so pure as to contain few or no spores, the air of cities, on the other hand, containing many. "If," he wrote in 1880, "all the results are compared that I have obtained until now, it seems to me that it can be affirmed that the dust, suspended in atmospheric air, is

the exclusive origin, the necessary condition of life in infusions." And he added: "What would be most desirable would be to push those studies far enough to prepare the road for a serious research into the origin of various diseases."

The action of those little organisms in the air, the causes not only of fermentation but also of putrefaction and disorganization, was dawning upon him, but it was some years before he applied this intuition to real experiment. It may be said that he established the following facts, until then not understood:—Ferments are living beings. There is a special ferment corresponding to each kind of fermentation. Ferments are not born spontaneously.

He now turned his attention to the study of wine, for he was always interested in the practical application of his discoveries. "Might not the diseases of wines," he said, "be caused by organised ferments, microscopic vegetations, of which the germs would develop when certain circumstances of temperature, of atmospheric variation, of exposure to air, would favour their evolution or their introduction into wines? I have indeed reached this result, that the alterations of wines are coexistent with the presence of, and multiplication of, microscopic vegetation."

He proved that it is the action of certain ferments present in the air, and which cover the grapes ripened in the open, which causes the fermentation necessary to produce alcohol, and that the only safe means of checking the development of destructive ferments in the wine was to raise it to a temperature of from 120° to 140° F. "I have also ascertained," he wrote, "that wine was never altered by that preliminary operation, and as nothing prevents it afterwards from undergoing the

gradual action of the oxygen in the air—the only cause, as I think, of its improvement with age—it is evident that this process offers every advantage." Several wine merchants adopted this precaution with success, and an experiment was later made with some wine for the fleet, which was sent to sea for ten months. Other wine that had not been heated was found to be bad at the end of the time, while the previously heated wine was as good as ever.

In the year 1865 he was called away from his study of ferments by his friend Dumas, who begged him, on the part of the Government, to come to the assistance of a great industry which was being threatened with extinction, and before which other experts stood powerless to advise. The silk industry of France had been established for many generations, and had brought in, twenty years previously, the enormous sum of £4,000,000. But a disease broke out in the silkworm nurseries, destroying millions of worms and spreading to every country that bred them. "Pébrine," the name given to this disease, had brought the industry to the lowest ebb, was causing desolation among thousands of workpeople, and could not be traced to any definite cause.

Pasteur set out at once to the stricken provinces, and tried to collect information wherever he went. He could get but contradictory and confused answers, but he was not easily dismayed by difficulties. He settled down in a small silkworm factory at Alais, and submitted specimens of diseased moths, eggs, and worms to microscopical examination. For two years he worked patiently, slowly, and surely, coming to definite conclusions as to the extent of the disease and the best method of preventing it. Finally his results were published, and the methods he advised were so simple

that every producer could follow them. Roughly, this is what he recommended :—

"At the time when the moths leave their cocoons and mate with each other, the cultivator separates them and places each female on a small square of linen, where she lays her eggs. The moth is afterwards pinned up in a corner of the same square of linen where she gradually dries up; later on, in autumn or even in winter, the withered moth is moistened in a little water, pounded in a mortar, and the paste examined with a microscope. If the least traces of corpuscles appear, the linen is burnt, together with the seed, which would have perpetuated the disease."

A year later Pasteur returned to Alais eagerly awaiting the result of his suggestions, and it was a great joy to him to find that those who had been guided by his advice, who had practised seeding according to his prescriptions, had met with complete success ; others, who had not troubled to do so, had failed as in previous years. France was slow in generally adopting the means suggested, but Austria and Italy did so, and in due time France also was convinced, while Austria, in 1868, gave to Pasteur the prize "for discovering a preventive and curative remedy against pébrine." Eleven years later he represented France at a great International Congress of Silkworm Culture at Milan, in the course of which he visited a large silkworm establishment named after him. In a letter to his old friend and master, Dumas, he wrote: "I very much regret that you are not here, you would have shared my satisfaction. Here from July 4th sixty or seventy women are busy for ten hours every day with microscopic examinations of absolute accuracy. I never saw a better arranged establishment. 400,000 moth-cells

are put under the microscope every day. The order and cleanliness are admirable : any error is made impossible by a second test following the first."

Sudden illness now attacked Pasteur, which very nearly robbed the world of him who was destined to carry out such great work in the future, whose life has saved thousands of lives already, and whose discoveries were to open a new era to the world of science and medicine. At the age of 45 he had a stroke of apoplexy, and for many weeks lay between life and death. Some of the greatest scientists of France nursed him tenderly at his bedside. But as time passed his friends were gratified to find that not only his physical paralysis gradually disappeared, but his mental activity returned to its normal condition, and after a long rest he was able to return to his labours, to complete the great work of his life. In his return to health he saw only the new means of work and hurried back to his silkworm experiments.

The years that followed gave a new direction to Pasteur's thoughts, but before describing this it is well to mention here the study of beer and its diseases to which Pasteur devoted much attention in the year 1871. To do so on a larger scale than the small breweries of France afforded, he visited England, where he was courteously received by the manager of one of the largest breweries in London. He was shown round the works and he made some microscopic examinations of yeast and samples of beer. He certified the existence of certain noxious ferments which would inevitably spoil the beer then being produced, and stated that "every marked alteration in the quality of the beer coincides with the development of micro-organisms foreign to the nature of true beer yeast." The brewer's interest was

roused, and he confessed that in the brewery there was a quantity of beer which had gone wrong only a fortnight after it was made, and was undrinkable, though he could assign no cause for the failure. "I examined it with a microscope," said Pasteur, "and could not at first detect any ferments of disease; but guessing that it might have become clear through the long rest, the ferments now inert having dropped to the bottom of the reservoirs, I examined the deposit at the bottom of the vats and found that it was entirely composed of filaments of disease unmixed with the least globule of alcoholic yeast. The fermentation of that beer had therefore been exclusively a morbid fermentation."

He was pleased to find, a week later, that the yeast in the whole brewery had been changed, and that a microscope had been procured. This eminently practical application of his teaching gave great pleasure to Pasteur. His final conclusions on the subject of beer were these :—

(1) Every alteration either of the infusion of malt or of the beer itself depends on the development of micro-organisms which are ferments of disease.

(2) These germs of ferments are brought by the air, by the ingredients, or by the apparatus used in breweries.

(3) Whenever beer contains no living germs it is unalterable.

He recommended heating the beer, like the wine, to destroy destructive ferments, and this process of heating, without boiling, came to be called "pasteurising."

In breweries, as in all chemical work, he insisted upon the necessity of absolute cleanliness. He carried this principle rigidly into practice, carefully wiping

every glass or instrument before use, noting every speck of dust.

Shortly after his illness another great trial was in store for Pasteur, for to him, as to all patriotic Frenchmen, the year 1870–71 was darkened by the disastrous war with Prussia, by defeat and humiliation, besides terrible personal anxiety. His friends persuaded him to leave Paris; a half paralysed man could not fight, and would only be a useless mouth to feed, they pretended.

He went with his wife and daughter to Arbois, whence they watched the course of the war with the uttermost bitterness of feeling, whilst the son, a young student, went to the front as a volunteer. France was unprepared, while Prussia was armed and ready to the last button; no devotion to his country, no fervent desire to fight and bleed for her, could make the untrained Frenchman equal to the fully-trained, fully-prepared Prussian. It is no use entering into the details of that sad time, the iron of humiliation of his beloved France bit into the very soul of Pasteur, and he never forgave his country's enemy.

Pasteur's patriotism was a very real factor in his life. Whenever he could help the industries of France, raise her in the opinion of other countries, add lustre to her greatness, his joy was intense. It was one day, when he had made a very important discovery, *i.e.*, the vaccine to inoculate against anthrax, to which I shall refer later, that he said: "Nothing would have consoled me if this discovery had not been a French discovery!"

His great wish was that France, after her crushing defeat, should regain her great place among the nations by means of scientific triumphs.

It was terrible, during the war, to see how little the

French surgeons had applied the teaching of Pasteur to their own science. England had given to the world the man who was able to apply Pasteur's theory of germs to his own profession. Lister had realised as early as 1867 that living organisms and infectious germs in the air, the existence of which Pasteur had proved, were capable, not only of contaminating liquids and setting up putrefaction, but also were elements of danger, often of death, in wounds. He originated modern surgery. Sponges, drainage tubes, dressings, instruments, everything coming in contact with the wound was submitted to the most minute precaution of chemical cleanliness, and at once the surgeon became, what he now is, a saviour of life, not the executioner he had too often been in pre-antiseptic days. But during the Franco-Prussian war these truths had not yet penetrated to the ambulance tents. Sedillot writes from the war: "The horrible mortality amongst the wounded in battle calls for the attention of all the friends of science and humanity. The surgeon's art, hesitating and disconcerted, pursues a doctrine whose rules seem to flee before research. Places where there are wounded are recognisable by the stench of suppuration and gangrene."

Hundreds and thousands of wounded succumbed, not to their original wound, nor to the operation, but on the 8th or 9th day to gangrene or erysipelas, diseases introduced into the wound by the dust in the air, by the dressings, or even by the surgeon's hands; preventable diseases, but which were to the surgeon of the day a mystery he could not solve, and before which he was impotent.

During his experiments and researches with ferments the idea was constantly present in Pasteur's mind that contagious diseases were probably due to the virus

ferments, that is, the ferments of poisonous substances which invade the body of animal or man as infinitely small organic beings and then multiply and gradually disorganise the living tissues. He was slow to accept these flashes of insight unless he could obtain positive proof of his beliefs, but the hope of being able to relieve the suffering of mankind by such proof urged him to yet greater effort, to patient, untiring energy and work. The death of his children, the loss of the many brave young heroes in the ambulance tents during the war, the epidemics he had witnessed, all this human suffering weighed upon him and determined him to do his utmost to solve the problems which medical men, working alone, seemed unable to fathom; but he was met with a torrent of abuse and opposition. The doctors of the day, with a few notable exceptions, resented the invasion of what they considered their special domain by a mere chemist, who tried to explain matters they did not understand by experimental proof. Pasteur was anxious to possess the status which would allow him to speak with greater authority on medical matters, and he accepted in 1873 the post of Free Associate of the Academy of Medicine, which enabled him to attend the meetings, which he faithfully did for many years. His associates were men mostly opposed to his doctrines, men who vigorously denounced in grandiloquent speeches the theory of bacterial origin, men who would not or could not open their eyes to what experimental research was bringing to light. But Pasteur, invariably patient when ignorance did not arise from prejudice, denounced those speakers who clung so tenaciously to worn-out theories. "The relationship is certain, indisputable," he cried, "between the disease and the presence of organisms."

At the same time it is delightful to read of Pasteur's

wonderful modesty and self-depreciation, which was absolutely genuine. In one of his speeches at the Academy he exclaimed :—

"I say it here with no sham modesty : I have always considered that my only right to a seat in this place is that given me by your great kindness, for I have no medical or veterinary knowledge. I therefore consider that I must be more scrupulously exact than anyone else in the experiments which I have the honour to report to you ; I should promptly lose all credit if I brought you erroneous or merely doubtful facts. If ever I am mistaken, a thing which may happen to the most scrupulous, it is because my good faith has been greatly surprised. On the other hand, I have come amongst you with a programme to follow which demands accuracy at every step. I can tell you my programme in two words, I have sought for 20 years, and I am still seeking, spontaneous generation, properly so called. If God permit, I shall seek for 20 years and more the spontaneous generation of transmissible diseases. In these difficult researches, whilst sternly deprecating frivolous contradiction, I only feel esteem and gratitude towards those who may warn me if I should be in error."

But although he had many opponents, he had also many faithful and devoted followers, the greatest scientists in England, Russia, Germany, and France, besides young students, who flocked to the Academy of Medicine every week, in the hope of hearing Pasteur deliver some communication "which," as one of them wrote, "resolves each difficulty by an easily interpreted experiment, delightful to the mind, and at the same time so incisive that it is as satisfying as a geometrical demonstration, and gives an impression of security."

These at least realized that the coming science of hospitals was to be found in the chemist's laboratory.

Can you realize, I wonder, what strides medicine and surgery have made since those dark days, 30 or more years ago? One hundred and fifty years ago there was a great belief in cauterizing wounds by fire, boiling liquids and disinfecting substances, and there was a belief, not founded on any scientific fact, that wounds should be kept from air and not touched by hands or instruments; but these customs were supplanted in the 19th century by poultices, dressings consisting of old linen, and endless ointments. An occasional voice of protest was raised, but no one saw the reason for cleanliness, and the death-rate increased, the mortality after amputations in 1868 in France being over 60 per cent. A well-known surgeon at the Charité Hospital in Paris, speaking to his pupils, said that "when an amputation seems necessary think ten times about it, for too often when we decide upon an operation we sign the patient's death warrant." But the danger to which wounds were exposed, not only by impurities in the air, but also by dirty hands, impure water, and dressings allowed to lie about on dirty tables, etc., had at that time not occurred to the average surgeon of the day. He wore his dirtiest coat, stained with blood and matter, in the operating room. It is primarily due to Pasteur's discovery of organic germs in the air and in every kind of unsterilised article that modern surgery owes its success. Lister, our great countryman, was the first to apply this knowledge and to revolutionize surgery. Let me here quote a letter written by Lister to Pasteur, where he modestly passes on to the French scientist the praise given to him:—

"My dear Sir,—Allow me to beg your acceptance of

a pamphlet containing an account of some investigations into the subject which you have done so much to elucidate, the germ theory of fermentative changes. I flatter myself that you may read with some interest what I have written on the organisms which you were the first to describe in your works. I do not know whether the records of British surgery ever meet your eye. If so, you will have seen, from time to time, notices of the antiseptic system of treatment, which I have been labouring at for the last nine years to bring to perfection. Allow me to take this opportunity to tender you my most cordial thanks for having, by your brilliant researches, demonstrated to me the truth of the germ theory of putrefaction, and thus furnished me with the principle upon which alone the antiseptic system can be carried out. Should you at any time visit Edinburgh, it would, I believe, give you sincere gratification to see at our hospital how largely mankind is being benefited by your labours. I need hardly add that it would afford me the highest gratification to show you how greatly surgery is indebted to you. Forgive the freedom with which a common love of science inspires me, and believe me, with profound respect,— Yours very sincerely, JOSEPH LISTER."

Professor Tyndall, writing to Pasteur a little later says :—

"For the first time in the history of science we have the right to cherish the sure and certain hope that, as regards epidemic diseases, medicine will soon be delivered from quackery and placed on a real scientific basis. When that day arrives humanity, in my opinion, will know how to recognize that it is to you that will be due the largest share of her gratitude."

Even before the war Tyndall had called attention to

Lister's success, but in France, and even in England, Lister's teaching had mostly fallen on deaf ears, and it was long before his methods were universally approved and adopted.

But what is the result of their adoption, of the teaching of these two great men? Operations formerly undertaken as a last resource and almost with a certainty of death are now looked upon as being of slight risk, and the death-rate has fallen considerably; big operations, which formerly could never have been attempted, for they would inevitably have ended fatally, are now done daily, and hundreds of thousands of useful lives, formerly sacrificed to ignorance, are snatched from suffering and disease and put back to fulfil their destiny in the world. Can any word of ours ever express the gratitude we owe to such men?

The National Assembly voted an annuity of £480 for the benefit of Pasteur, and Paul Bert, a member, wrote concerning it:—

"Such an assurance of gratitude, given by a nation to men who have made it richer and more illustrious, honours it at least as much as it does them." He then enumerated Pasteur's discoveries, and stated how they had enriched his country, without, as he said, retaining the least share of it himself. "Pasteur's discoveries," he continued, "after throwing a new light on the obscure question of fermentations and of the mode of appearance of microscopic beings, have revolutionized certain branches of industry, of agriculture, and of pathology."

Our great physiologist, Professor Huxley, once said that "Pasteur's discoveries alone would suffice to cover the war indemnity of £200,000,000 paid by France to Germany in 1871."

Some of his friends now advised him to retire from work and take care of his health, which had always given him trouble since his illness, but to Pasteur life meant work, and he would as soon have contemplated giving up the one as the other. Greater victories in the fields of science were in store for him, and, fortunately for humanity, many years still rich in work.

In 1877 we find Pasteur at a new and laborious work. The agriculture of France was being ruined by constantly recurring and increasing epidemics of anthrax, flocks of sheep, besides cows and horses, being decimated, and in some parts of the country 20 to 50 per cent. of the sheep succumbed. At times it appeared to be stamped out, and then it would break out afresh, killing those attacked in a few hours, and resisting every treatment. Some special fields and neighbourhoods appeared to harbour the infection, but how the disease arose and how it could be checked defied the researches of the veterinary authorities and medical experts. Even human beings were attacked, the smallest scratch appearing to be an open door through which the disease could enter. In Russia it was even worse, for there 56,000 head of cattle died in two years.

Forty years earlier certain little rod-like bodies in the blood of those dying from anthrax had been pointed out, and Pasteur had devoted much attention to the subject. Dr. Davaine, after studying Pasteur's works on ferments, asked himself whether these little bodies might not act as ferments and be the cause of the disease. Others disputed this.

At last Pasteur attacked the subject. He took a drop of the blood of an animal which had died from anthrax, and made a culture of it, that is, he laid it on some medium, broth or yeast water, suitable to the

development of the rod-like bodies, or bacteria. After a few hours these bacteria had increased and multiplied enormously. A drop from this tube of broth was put into another tube, and from this a drop was placed in yet another tube, and so on till the hundredth culture had been reached. An animal, into which a few drops of this hundredth culture were injected, died as inevitably from anthrax as if those drops came direct from an anthrax victim. It was thereby proved that the bacteria which had multiplied in each culture were the cause of the disease. Besides this, the microscope revealed the fact that within a few hours of placing a drop containing the bacteria into the broth medium the bacteria could be seen which again reproduced themselves, and Pasteur reported that "one single bacterium in the drop which is sown multiplies during the following hours, and ends by filling the whole liquid with such a thickness of bacteria that, to the naked eye, it seems as if carded cotton had been mixed with the broth."

Mr. Chamberland, his associate in this work, added: "By his admirable process of culture outside the organism, Pasteur shows that the rods which exist in the blood, and for which he has preserved the name of bacteria, are living beings capable of being indefinitely reproduced in appropriate liquids, after the manner of a plant multiplied by successive cuttings. The bacterium does not reproduce itself only under the filamentous form, but also through spores or germs, after the manner of many plants which present two modes of reproduction, by cuttings and by seeds."

By these discoveries, by, as Tyndall puts it, "his extraordinary faculty of combining facts with the reasons of those facts," Pasteur foresaw the day when all contagious diseases would be analysed as anthrax was analysed, and that methods would be found for

destroying the power of all destructive bacteria, or microbes, as they now came to be called. A presentiment of the greatness of such a discovery fired Pasteur to new and renewed energy and work. The thought was at that time always present with him that humanity might be saved from endless suffering by the knowledge of its infinitely small foes. "It is terrifying," he said in a lecture, "to think that life may be at the mercy of the multiplication of those infinitesimally small creatures; it is also consoling to hope that science will not always remain powerless before such enemies, since it is already now able to inform us that the simple contact of air is sometimes sufficient to destroy them."

Having completed the preliminary studies in his laboratory, Pasteur started for some of the most afflicted parts of France where anthrax had made great ravages. In Beauce alone, where he went, the loss in some years was said to have amounted to £800,000. Pasteur had several assistants working with him, and one of them, Dr. Roux, gives this account of their work:—

"Our guide was M. Boutet, who had unrivalled knowledge of the anthrax country, and we sometimes met M. Toussaint, who was studying the same subject as we were. We have kept a pleasant memory of that campaign against anthrax in the Chartres neighbourhood. Early in the morning we would visit the sheep-folds scattered on the wide plateau of the Beauce, dazzling in the splendour of the August sunshine; then the dead sheep were examined in M. Rabourdain's knacker's yard, or in the farmyard. In the afternoon we edited our experiment note-book, wrote to Pasteur and arranged for new experiments. The day was well filled, and how interesting and healthy was bacteriology practised in the open air.

"On the days when Pasteur came to Chartres we did not linger over our lunch at the hotel, we drove over to St. Germain, where M. Manouri had kindly put his farm and flocks at our disposal. During the drive we talked of the week's work and of what remained to be done. As soon as Pasteur left the carriage he hurried to the fold. Standing motionless by the gate he would gaze at the lots which were being experimented upon with a careful attention which nothing escaped; he would spend hours watching one sheep which seemed to him to be sickening. We had to remind him of the time and to point out to him that the towers of Chartres Cathedral were beginning to disappear in the falling darkness before we could prevail upon him to come away. He questioned farmers and their servants, giving much credit to the opinions of shepherds, who, on account of their solitary life, give their whole attention to their flocks, and often become sagacious observers."

One experiment, among others, was to make certain how the infection entered the body of the animal. Some anthrax spores were scattered upon hay given to certain sheep. The hay was eaten, but no anthrax followed. Pasteur then mixed with another lot of hay some prickly plants, such as thistles, capable of pricking the mouth or throat of the animal. This time, after the anthrax had been added, several of the animals contracted the disease, and Pasteur now had the proof that the bacteria entered the blood directly and were not absorbed by the stomach. The infected blood of an animal which has died from anthrax entering a scratch or cut in the hand of a man will infect him. In countries where anthrax is prevalent he could now warn farmers against allowing thistles or other prickly plants to grow on the land. "It will also be necessary," said Pasteur, "to

avoid all probable diffusion of anthrax germs through the carcases of animals dying from that disease, for it is likely that the department of Eure-et-Loire contains those germs in greater quantities than the other departments, anthrax having long been established there. It always goes on, dead animals not being disposed of so as to destroy all germs of ulterior contagion." The animals which had died from anthrax were often buried in the fields where they had succumbed, and Pasteur was puzzled to find an explanation of the fact that the infection appeared to haunt these fields. He was convinced that this was due to the buried animals, the bacteria still alive within them and in the soil around them, for he had proved that the spores found in the graves ten or twelve years after death were still active and virulent.

But how did the bacteria return to the surface and re-infect the living animals grazing on it? The solution of this mystery is so well described by his excellent biographer, Vallery-Radot (from whose work most of this lecture has been abstracted), that I cannot do better than repeat it :—

"One day in one of his habitual excursions with Messrs. Roux and Chamberland to the farm of St. Germain, near Chartres, he suddenly perceived an answer to the enigma. In a field recently harvested he noticed a place where the colour of the soil differed a little from the neighbouring earth. He questioned M. Manouri, the proprietor of the farm, who answered that sheep dead from anthrax had been buried there the preceding year. Pasteur drew near and was interested by the masses of little earth cylinders, those little twists which earth worms deposit on the ground. Might that be, he wondered, the explanation of the origin of the germs

which reappear on the surface? Might not the worms returning from their subterranean journey, in the immediate neighbourhood of graves, bring back with them anthrax spores and thus scatter the germs so exhumed? That would, again, be a singular revelation, unexpected, but quite simple, due to the germ theory. He wasted no time in dreaming of the possibilities opened by that preconceived idea, but, with his usual impatience to get at the truth, decided to proceed to experiment."

On his return to Paris, Pasteur spoke to Bouiley of the part of germ carriers possibly played by earth worms, and Bouiley obtained some worms which had appeared on the surface of pits where animals dead from anthrax had been buried some years before. Bouiley was invited to come to the laboratory to see the bodies of these worms opened; anthrax spores were found in the earth cylinders which filled their intestinal tube. "At three different times, within these two years," Pasteur announced to the Academy, "the surface soil of those same pits has presented anthrax spores." "This fact has been confirmed by recent experiments on the soil of the Beauce farm; particles of earth from other parts of the field had no power of provoking anthrax."

Having proved all this, Pasteur now experimented for long weeks, with endless tests and constant patience, to find a vaccine by which he might vaccinate animals against anthrax. It was found that the bacteria could no longer be cultivated at a temperature of 113° F. At a temperature of 108° they could still be cultivated, but the spores did not develop. "At that extreme temperature," Mr. Chamberland explains, "the bacteria still live and produce themselves, but they have never given

any germs. Thenceforth when trying the virulence of the phials of six, eight, ten, or fifteen days, we have found exactly the same phenomena as for chicken cholera. After eight days, for instance, our culture, which originally killed ten sheep out of ten, only kills four or five; after ten or twelve days it does not kill any; it merely communicates to animals a benign malady which preserves them from the deadly form."

In this manner vaccine was prepared and sent to all parts of the world. "What therefore is easier," said Pasteur, "than to find in these successive poisons virus capable of giving anthrax to sheep, cows, and horses without making them perish, and assuring them of ulterior immunity from the deadly disease. We have practised that operation on sheep with the greatest success. When the season comes for sheep folding in Beauce we will apply it on a large scale." This was done. Sheep were vaccinated and afterwards resisted all attempts to give them anthrax, while others, unvaccinated, succumbed every time.

Every kind of experiment and test was tried, the new vaccine triumphed everywhere. Once more Pasteur had benefited his country and all agriculture past all computation.

But it was not without bitterness that Pasteur had carried on his investigations. In the preaching of his new doctrines he had had formerly to encounter the opposition of the doctors of the day, now it was the veterinary surgeons who rose up and denounced him. Pasteur never objected to faithful criticism. "Do repeat to me every criticism you hear," he once wrote to a friend, "I much prefer that to praise, which is barren unless encouragement is wanted, which is certainly not my case. I have a lasting provision of faith and fire." And

again, "Worship the spirit of criticism. It is indeed a hard task, when you believe you have found an important scientific fact, and are feverishly anxious to publish it, to constrain yourself for days, weeks, years sometimes, to fight with yourself, to try and ruin your own experiments, and only to proclaim your discovery after having exhausted all contrary hypothesis. But when, after so many efforts, you have at last arrived at a certainty, your joy is one of the greatest which can be felt by a human soul, and the thought that you have contributed to the honour of your country renders that joy still deeper."

It was only when accused of bad faith in his work, when his word was doubted, or when opposition arose from obstinacy, that his wrath was roused and he crushed his opponents with the strength and certainty of his convictions.

It was during this time that Pasteur became interested in the question of the high mortality among women after child-birth. It was a terrible fact that the poor women of Paris looked upon the Maternity Hospital at that time as the ante-room to death. When we read of 64 deaths after 347 confinements, we can only wonder how any poor creature could be persuaded to enter its doors. Various theories were propounded as to the cause of this high mortality, but nothing was proved. Things were better in Edinburgh, where Lister had introduced antiseptic treatment of these cases, and other countries had imitated his example with success. Pasteur now discovered the microbe of infection, and armed with this knowledge he attended a discussion on the subject at the Academy of Medicine.

Various causes for the frequency of puerperal fever were suggested, but Pasteur would have none of them.

"None of these things cause the epidemics," he interrupted, "it is the nursing and medical staff who carry the microbe from an infected woman to a healthy one." And as the orator replied that he feared that the microbe would never be found, Pasteur went to the black-board and drew a diagram of the chain-like organism, saying: "There, that is what it is like."

"Chamberland and I assisted him in those studies," writes M. Roux. "It was to the Maternity that we went most frequently, taking our culture tubes and sterilised pipettes into the wards or operating theatre. No one knows what feelings of repulsion Pasteur had to overcome before visiting patients, and witnessing post-mortem examinations. His sensibility was extreme, and he suffered morally and physically from the pains of others. The cut of the lancet opening an abscess made him wince as if he himself had received it. The sight of corpses, the sad business of examining them, caused him a real disgust; we have often seen him go home ill from the operating theatres. But his love of science, his desire of truth, were the stronger; he returned the next day."

Pasteur set himself vigorously to introduce reforms, insisting upon perfect cleanliness, making others understand, as he did, the danger of personal infection. Within ten years the death-rate at the Maternity Hospitals of Paris had fallen from between 100 to 200 per 1,000 to 3 and afterwards to 1 per thousand. It is to-day only 2 per 10,000.

But as soon as one difficulty was overcome another question arose to which he turned, always full of an enthusiastic desire to help to lighten the darkness of ignorance.

Before he had completed his research on anthrax, or

even contemplated the possibility of a prophylactic vaccine, Toussaint, a veterinary professor, sent to him, in 1880, the head of a cock which had died of chicken cholera, which is a disease that occasionally attacks the farmyard and destroys hundreds of fowls. Pasteur describes the symptoms thus: "The animal suffering from this disease is powerless, staggering, its wings droop and its bristling feathers give it the shape of a ball; an irresistible somnolence overpowers it. If its eyes are made to open, it seems to awake from a deep sleep, and death frequently supervenes after a dumb agony, before the animal has stirred from its place; sometimes there is a faint fluttering of the wings for a few seconds."

Others had already recognized in the blood of birds which had died from this disease the specific microbe. Pasteur found a suitable medium for its cultivation and wrote of it: "The facility of multiplication of the micro-organisms in the culture medium is really prodigious. In a few hours the most limpid broth becomes turgid and is found to be full of little particles of an extreme slenderness. Within a few days those beings, already so small, change into a multitude of specks so much smaller, that the culture liquid, which had at first become turgid, becomes nearly clear again, the specks being so minute as to be incapable of measurement, even approximately."

The flasks containing the cultures were generally used for experimental purposes within a few hours of their preparation, but it so happened that some of these flasks were overlooked, and when hens were inoculated with these forgotten cultures (then some weeks old) it was found that, although the hens sickened, they eventually recovered from the disease. These same

hens were then inoculated with fresh cultures, but they all resisted the disease. Pasteur at once realized that by this most fortunate chance a great discovery had been made. It was proved that the oxygen in the air had attenuated the cultures, that though the microbe could still be cultivated its virulence had so abated that it did not produce death in the host. At the same time hens which had received one such attenuated inoculation were no longer susceptible to the poison, they had acquired immunity. This discovery caused him later to search for the vaccine against anthrax, and opened his mind to the possibility of discovering a vaccine for each of the diseases that mankind suffer from.

In 1881 Pasteur was invited to attend the International Medical Congress in London to represent France. I saw him at the big inaugural meeting in St. James's Hall. The place was filled to overflowing. He was asked to sit on the platform with the most distinguished guests, and as he walked up the staircase he was recognized. At once a perfect storm of applause greeted him, the huge audience of medical men and scientists rose to their feet and cheered continuously for several minutes. He turned to Sir James Paget, the President of the Congress, saying uneasily: "I am afraid I have come late; all this, no doubt, is for the Prince of Wales." "No," said Sir James with his kind smile, "it is you they are all cheering."

"I felt very proud," he wrote to his wife, "not for myself—you know how little I care for triumph—but for my country, in seeing that I was specially distinguished among the immense concourse of foreigners, especially the Germans, who are here in much greater numbers than the French."

As far back as 1880 Pasteur had devoted some attention to hydrophobia. The older members of the community may still remember the occasional appearance of this horrible disease in England, although we have never been the victims of such constant and serious outbreaks as our neighbours on the Continent. Our island gives us some immunity, and has now made it possible, through the determination of Mr. Walter Long, lately President of the Local Government Board, to stamp it out entirely. This cannot be done in countries where re-infection may at any moment take place from the frontiers. There hydrophobia is still an illness much to be dreaded. It is directly infectious, that is, the infection can always be traced from a bite or tear from an infected animal, the poison being present in the saliva and entering directly into the blood of the person attacked. This poison may, however, linger for many weeks or months in some part of the body before it reaches the nervous centres where the disease develops, and this accounts for the fact that the incubation period varies widely, and is, in some cases, so very long. When the typical hydrophobia symptoms have developed, however, it is a terrible disease to witness. First come spasms, restlessness, and burning thirst which cannot be assuaged because the very sight or sound of water causes in the unfortunate patient strangling spasms in his throat, then follow violence and delirium, and after a day or two the patient dies from exhaustion. Up to 20 years ago we were utterly helpless to avert this dreadful suffering; the victim of a bite from a rabid dog saw death in its most horrible shape staring him inevitably in the face. In old days the fear of hydrophobia was so great that cases are known of people with rabies, or even suspected

of rabies, being shot, strangled, or suffocated like wild beasts.

Once more Pasteur came to our rescue. He had tried in vain to discover the specific microbe of the disease, which appeared to be invisible to human sight, but when he found that this seemed an impossible task he tried another means of combating the enemy. He thought that preventive medicine might step in during "the long period of incubation of hydrophobia, by attempting to establish during the interval before the appearance of the first rabid symptoms a refractory condition in the subject bitten."

Until he took up the study of the disease it was not known where the seat of it lay, and this seemed to Pasteur the first problem to solve. He inoculated into rabbits saliva taken from rabid dogs, but the incubation period was very long and the result was not always positive. He then tried inoculating the rabid blood into animals, but this had no result at all. "We must try other experiments," he said. He finally came to the conclusion that the seat of the disease was in the nervous system. "The seat of the rabid virus," wrote Pasteur, "is therefore not in the saliva only, the brain contains it in a degree of virulence at least equal to that of the saliva of rabid animals."

Trephining under anæsthetics, followed by inoculation of the virus, was performed on dogs, with the result that in every case hydrophobia invariably occurred in a very short time. Pasteur had not been able to find the microbe, but he now knew definitely where it flourished. I cannot do better than describe the next experiment in the words of Vallery-Radot, translated by Mr. Devonshire :—

"As soon as a trephined and inoculated rabbit died

paralysed, a little of his rabid medulla was inoculated into another; each inoculation succeeded another, and the time of incubation became shorter and shorter, until, after 100 uninterrupted inoculations, it came to be reduced to seven days. But the virus, having reached this degree, the virulence of which was found to be greater than that of the virus of dogs made rabid by an accidental bite, now became fixed; Pasteur had mastered it. He could predict the exact time when death should occur in each of the inoculated animals. His predictions were verified with surprising accuracy. Pasteur was not yet satisfied with this. He now wished to decrease the degrees of virulence; when the attenuation of the virus was once conquered it might be hoped that dogs could be made refractory to rabies. Pasteur abstracted a fragment of the medulla from a rabbit which had just died of rabies after an inoculation of the fixed virus; this fragment was suspended by a thread in a sterilised bottle, the air in which was kept dry by some pieces of caustic potash lying at the bottom of the vessel, which was closed by a cotton-wool plug to prevent the entrance of atmospheric dust. The temperature of the room where this desiccation took place was maintained at 23° C. As the medulla gradually became dry its virulence decreased, until at the end of 14 days it had become absolutely extinguished.

"This now inactive medulla was crushed and mixed with pure water, and injected under the skin of some dogs. The next day they were inoculated with medulla which had been desiccated for 13 days, and so on, using increased virulence until the medulla was used from a rabbit dead the same day. These dogs might now be bitten by rabid dogs given them as companions for a

few minutes, or even submitted to the intracranial inoculations of the deadly virus ; they resisted both."

Having proved these points to his own satisfaction, Pasteur asked the Minister of Public Instruction to appoint a Commission to verify his facts, and this was done. The carcase of a dog which had died from rabies was opened and a fragment of medulla was mixed with sterilised broth. Two dogs which had been previously vaccinated by Pasteur's method were present, also two others which had not been vaccinated, and two rabbits. All these animals were now inoculated with the broth. "M. Pasteur tells us," wrote a reporter present, "that, consid ring the nature of the virus used, the rabbits and the new dogs will develop rabies within 12 or 15 days, and that the two protected dogs will not develop it at all, however long they may be detained under observation."

The prophecy was accurately verified. Whenever a dog had been vaccinated he resisted every effort of infection, neither the bites of rabid animals nor direct intracranial injection of the virus produced any symptom of hydrophobia.

The Commission recommended the construction of large kennels where further experiments might be made, and where the question might be solved, whether inoculation of the vaccine was effectual in cases where the dog had already been bitten by a rabid animal. "What I want," wrote Pasteur, "is to obtain prophylaxis of rabies *after* a bite." It was impracticable to consider the possibility of vaccinating every dog in France against a possible infection, and yet, unless dogs could be made harmless, there was always the possibility of a man being fatally bitten.

He recommended the following experiment to his

assistant :—" When there is a good biting dog, have a pair of our dogs bitten, after which you will treat one of them so as to make him refractory (carefully taking note of the time elapsed between the bites and the beginning of the treatment). Mind you keep notes of every new experiment undertaken." "But even when," he writes elsewhere, "I shall have multiplied examples of the prophylaxis of rabies in dogs, I think my hand will tremble when I go on to mankind."

His researches were successful, and in March 1885 he writes to a friend :—" I have some new experiments on rabies on hand, which will take some months. I am demonstrating this year that dogs can be vaccinated or made refractory to rabies *after* they have been bitten by mad dogs. I have not yet dared to treat human beings after bites from rabid dogs, but the time is not far off, and I am much inclined to begin on myself, inoculating myself with rabies and then arresting the consequences, for I am beginning to feel very sure of my results."

By the middle of 1885 the kennels at Villeneuve were ready for the reception of 60 dogs, besides other animals used for experiments, and Pasteur had some rooms prepared for his own use, where he could spend days and nights near his researches. Although he was slowly becoming convinced that the vaccine, so successful in preventing rabies in animals that had been bitten by other rabid animals, could be used as advantageously on man, he still hesitated to take this decisive step.

But one summer day in 1885 an Alsatian woman entered his laboratory holding her little son, Joseph Meister, by the hand. Two days before, this little fellow had been walking alone to school when he was attacked by a mad dog, thrown to the ground and repeatedly bitten. A man had come to his rescue, and

had beaten off the dog, which ran back to his master whom he bit in the arm before he was shot. The boy's parents consulted a doctor, who wisely advised them to lose no time in taking the child to one who was not a doctor, but who could help them better than anyone else. The dog's master came also, but as the dog's teeth had not pierced his clothes Pasteur at once reassured him and sent him home. But what about the boy? Pasteur had to face the alternative, either to try the treatment, so far only tried on animals, or to leave the child to his horrible and inevitable fate. There was no third course. The child's suffering affected Pasteur very much. The little fellow had 14 wounds, many of them very deep, and Pasteur arranged at once for comfortable quarters for him and his mother, telling them to return a few hours later. He consulted with two of his assistants, wise men of experience, and they agreed that it was his obvious duty to vaccinate the boy at once. The first inoculation was made that evening; a few drops of the liquid were injected with a syringe into the patient's side, and the boy hardly felt it. "All is going well," wrote Pasteur a few days later, "the child sleeps well, has a good appetite, and the inoculated matter is absorbed into the system from one day to another without leaving a trace. It is true that I have not yet come to the test inoculations. If the lad keeps well during the three following weeks I think the experiment will be safe to succeed." His anxiety was intense. At night he could not sleep, thinking always of the little boy, of whom he had become very fond, dying from hydrophobia, if the treatment were after all in vain. By day he could fix his mind on no work, all his thoughts were with the child. The strain became greater as the inoculations increased in intensity, and after the twelfth dose, the

strongest, he had days of anxious waiting to see which would triumph, the original poison or the vaccine. Pasteur was persuaded to leave the boy under observation in Paris and to take a rest in the country, but even there the hourly fear of receiving bad news by telegram was almost too much for him. But the bad news never came. Instead he was able to write in August, "Very good news last night of the bitten boy. I am looking forward with great hopes to the time when I can draw up a conclusion. It will be 31 days to-morrow since he was bitten."

Pasteur's sympathy with suffering was so great that it needed all his love of science, all his convictions, that only by experiments could he hope for certain knowledge to enable him to perform the simplest operation on any animal. He admitted that he never could have had the courage to shoot a bird for sport.

It was now found necessary to prepare for the reception of patients who had been bitten by mad dogs, for the case of little Meister had created a great sensation. Here is Pasteur's second case, reported by Vallery-Radot :—

"The Mayor of Farlay wrote to him that, on October 14, a shepherd had been cruelly bitten by a rabid dog.

"Six little shepherd boys were watching over their sheep in a meadow ; when they suddenly saw a large dog passing along the road with hanging, foaming jaw. 'A mad dog!' they cried. The dog, seeing the children, left the road and charged them ; they ran away shrieking, but the eldest of them, Jupille, 14 years of age, bravely turned back in order to protect the flight of his comrades. Armed with his whip, he confronted the infuriated animal, which flew at him and seized his left hand. Jupille, wrestling with the dog, succeeded in

kneeling on him, and forced its jaws open in order to disengage his left hand; in so doing, his right hand was seriously bitten in its turn; finally, having been able to get hold of the animal by the neck, Jupille called to his little brother to pick up his whip, which had fallen during the struggle, and securely fastened the dog's jaws with the lash. He then took off his wooden shoe, with which he battered the dog's head, after which, in order to be sure that it could do no further harm, he dragged the body down to a little stream in the meadow and held the head under water for several minutes. Death being now certain, and all danger removed from his comrades, Jupille returned home. Whilst the boy's wounds were being bandaged the dog's carcase was fetched, and a necropsy took place the next day. The two veterinary surgeons who examined the body had not the slightest hesitation in declaring that the dog was rabid. The Mayor, who had been to see Pasteur during the summer, wrote to tell him that this lad would die a victim to his own courage unless the new treatment intervened. The answer came immediately: Pasteur declared that, after five years' study, he had succeeded in making dogs refractory to rabies, even six or eight days after being bitten; that he had only once as yet applied his method to a human being, but that once with success, in the case of little Meister, and that, if Jupille's family consented, the boy might be sent to him. 'I shall keep him near me in a room in my laboratory; he will be watched and need not stay in bed; he will merely receive a daily prick, not more painful than a pin-prick.' The family, on hearing this letter, came to an immediate decision; but between the day when he was bitten and Jupille's arrival in Paris six whole days had elapsed. Yet, however great were

Pasteur's fears for the life of this tall lad, who seemed quite surprised when he was congratulated on his courageous conduct, they were not what they had been in the first instance—he felt much greater confidence."

It is a pleasure to think that the life of this brave young shepherd was saved.

Physicians who wished to study his methods, besides people who had been bitten, now came from all sides and all countries, and Pasteur and his assistants had their hands full. He took the deepest personal interest in his patients, comforting, helping, administering to all their wants. There were many poor people amongst them, peasants from far away villages, who came hundreds of miles for this wonderful treatment, and he saw to it that they were properly housed and cared for. Children appealed to him most, and he could never be reconciled to their sufferings. Among his earlier cases there was one, a little girl of ten, who had been terribly bitten on the head 37 days before she was brought up for treatment. He realized at once that the case was hopeless and that the child was doomed, and he was very loth to try the treatment at all, for, he argued, the issue was almost sure to be fatal, and in that case others under treatment would lose their faith, and those who had not yet come might hear of it and refuse to be vaccinated. But the parents so begged him to try to save their child that he consented. She was inoculated and returned home, but some weeks later the inevitable signs of rabies showed themselves and Pasteur was informed. He hurried to her bedside and fresh inoculations were tried, but in vain. As she became worse she begged him to stay by her and he did so, only leaving her when she was at the point of death. But in almost all cases he had the joy of seeing his patients recover

and of receiving letters from all parts of the world in grateful remembrance of the care he had bestowed upon them. Here is another story told by Vallery-Radot :—

"During the early part of March, Pasteur received 19 Russians. They had been attacked by a rabid wolf and most of them had terrible wounds ; one of them, a priest, had been surprised by the infuriated animal as he was going into church ; his upper lip and right cheek had been torn off, his face was one gaping wound. Another, the youngest of them, had had the skin of his forehead torn off by the wolf's teeth ; other bites were like knife cuts. Five of these unhappy wretches were in such a condition that they had to be carried to the hospital as soon as they arrived. The Russian doctor who had accompanied these peasants related how the wolf had wandered for two days and two nights tearing to pieces everyone he met, and how he had finally been struck down with an axe by one of those he had bitten most severely. Because of the gravity of the wounds and in order to make up for the time lost by the Russians, Pasteur decided on making two inoculations every day, one in the morning and one in the evening. The patients at the hospital were inoculated there. The fourteen others came every morning in their fur coats and caps with their wounds bandaged, and joined without a word the motley groups waiting treatment at the laboratory—an English family, a Basque peasant, a Hungarian, etc. In the evening the dumb and resigned band of peasants came again to the laboratory door. They seemed led by fate, heedless of the struggle between life and death of which they were the prize. 'Pasteur' was the only French word they knew, and their set and melancholy faces brightened in his presence as with a ray of hope and gratitude. Their

condition was the more alarming because a whole fortnight had elapsed between their being bitten and the date of the first inoculation. Statistics were terrifying as to the result of wolf bites, the average proportion of deaths being 82 per 100. General anxiety and excitement prevailed concerning the hapless Russians, and the news of the death of three of them produced an intense emotion. Pasteur had unceasingly continued his visits to the hospital. He was overwhelmed with grief. His confidence in his method was in no wise shaken. The general results would not allow it. But questions of statistics were of little account in his eyes when he was the witness of a misfortune; his charity was not of that kind which is exhausted by collective generalities, each individual appealed to his heart. As he passed through the wards of the hospital each patient in his bed inspired him with deep compassion. And that is why so many who only saw him pass, heard his voice, met his pitiful eyes resting on them, have preserved of him a memory such as the poor had of St. Vincent de Paul. 'The other Russians are keeping well so far,' declared Pasteur, and whilst certain opponents in France continued to discuss the three deaths, and apparently saw naught but those failures, the home-coming of the 16 survivors was greeted with an almost religious emotion. Other Russians before them had been saved, and the Tsar, knowing these things, desired his brother, the Grand Duke Vladimir, to bring to Pasteur an Imperial gift, the Cross of the Order of St. Anne of Russia in diamonds. He did more; he gave £4,000 in aid of the proposed Pasteur Institute."

The plan was now generally approved to create an Institute in Paris for the preventive treatment of hydro-

phobia and for research on contagious diseases. The Institute was to be called after Pasteur, and public subscriptions were invited. The enthusiastic admiration all France felt for her great scientist now became evident; and not only France, for from Italy, German Alsatia, Turkey, and other countries contributions poured in. President Carnot opened the Institute in person in November, 1888, and Pasteur received the ovation due to him. But he was a broken and tired old man, and it was sad to see how his hard work and the opposition he had so often encountered had aged him. "Our only consolation," wrote Pasteur at about this time, "as we feel our own strength failing us, is to know that we may help those who come after us to do more and to do better than ourselves, fixing their eyes as they can on the great horizons of which we only had a glimpse." If his health was broken his spirit was not. As we become old we are a little apt to linger over the glories of our young days. People and things are not what they were! But to a mind like Pasteur's the future was only full of promise, of the realization of dreams he had dreamt and had not had the time to mature.

Every morning he went through his hospital wards, attending to every detail of the work, seeking information about each case.

On his 70th birthday, December 27, 1892, he received a splendid reception in the great theatre of the Sorbonne, in Paris. Representatives from many foreign countries were present, as Pasteur entered, leaning on the arm of President Carnot. Many addresses were presented to him, that from England being brought by Lord Lister. "You have," said he, "raised the veil which for centuries had covered infectious diseases, you have dis-

covered and demonstrated their microbian nature." "More fortunate than Harvey and than Jenner," said Professor Brouardel, "you have been able to see the triumph of your doctrines; and what a triumph!"

This was his last public honour. Pasteur's days were drawing to an end. He was taken ill towards the end of the following year, lingered on for some months, and died, in the midst of his family, on September 28, 1895.

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the attacks which have been made against the researches that the Society has been formed to defend.

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