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TREATMENT OF RESEARCH

THE 26th of December last was cold and misty as I passed through the gateway of Notre-Dame at 8 A.M. to take part in the funeral service of a man who had died a year and two months before. This man was the son of a tanner, and although he had lived for seventy-three years he knew not the world as most human beings know it, having opened up a world of his own in which he lived, moved, and worked. It was singular to think that this man, so perfectly simple-minded to the last, was brought, at the time of his death, to this temporary resting-place amidst all the pomp of a State funeral, in a city whose people know how to honour the living as well as the dead; and whose loss was felt to be the loss of all nations. After wandering about in the midst of the vast cathedral, I came at length upon the object of my search, the little chapel containing the remains of Louis Pasteur. Around this spot the immediate members of the family soon gathered, and presently the scene was changed from one of silence and solitude into one of ecclesiastical magnificence, with the rich tones of the organ pealing forth the dirge, and stringed instruments and voices filling the air with divine melody.

Notwithstanding the efforts of the family to keep the ceremony strictly private, it was impossible to restrain the intense enthusiasm of the public, who showed their reverence all along the line of route from the cathedral door, through streets some of which were named after him, to the Pasteur Institute. Here were assembled, for the second time, representatives of the Government, members of the French Academy, and delegates from the universities and scientific societies of Europe. At the entrance to the tomb a tribune was raised, from which laudatory orations were delivered in various languages before a dense concourse of people who had come from great distances to be present. Above the gateway of the tomb were the simple words, *Ici repose Pasteur.*

The crypt wherein he reposes was artificially illuminated through cupolas of pale yellow Algerian marble shedding a soft light throughout the interior, revealing a scene of exquisite beauty and grace. All

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around, the walls and roofs told mutely, but eloquently, of a life which had been given up to discovering the causes of death. Strange to say, the design of this beautiful tomb was suggested by one built 1,456 years ago at Ravenna, by, and for, the Christian Empress Placidia, daughter of Theodosius the Great, where it was seen by Pasteur's son, under whose fostering care and that of the family the idea was now developed. Instead, however, of the walls representing works of science as in this case, they of the fifth century represented the Apostles and the triumph of the Christian faith. These were the Dark Ages of history, when the light of Christianity was only beginning to be diffused over the land, and science lay crushed under the heel of persecution. Here, then, was surely a wondrous occasion, the tomb of an early Christian Empress forming a model for the tomb of a latter-day man of science, with a religious and academic service happily combined, taking place in the presence of all manner of thinkers in perfect unity and harmony. After this ceremony was over admission was given to the public, when 25,000 persons visited the tomb.

Two months after this I presented myself early one morning at the Institute to visit my friend Madame Pasteur, who still occupies the residence connected with the laboratory, as neither M. Duclaux (the new director) nor M. Roux would permit her to leave the home she had shared from the beginning with the master whom they loved and revered. Here she spends her time in taking an interest in all the work going on; in wandering about among the golden laurel wreaths and works of art showered upon her husband during life; and in taking charge of the innumerable Grand Crosses, medals, and other beautiful and treasured tokens of esteem.

As the people were beginning to assemble for the anti-rabic inoculations, and I was anxious to visit the laboratory, we wended our way in that direction first. Entering the passage which led to these apartments, we stopped at a door on the right which I was told I might enter. On the other side of this door I found myself within a glass enclosure designed with a view to preventing the ingress of dust to the sanctum beyond. In the far corner of this dark room sat a trained assistant at a table under a single light. He was busy cutting up the spinal cords of rabbits that had died of dumb rabies, and which were brought to him suspended in glass jars by an assistant who never spoke. These little spinal cords looked like mere threads, and were in every stage of desiccation, from the innocuous and quite dry, to the most virulent, still fresh and moist. In silence each labelled jar was brought from its wired cupboard in proper sequence, and the previous jar taken away. When these various marrows were mixed with a small quantity of bouillon, a row of covered and labelled wine-glasses denoted that all was ready. It was interesting to watch how every precaution was

taken to prevent inimical germs getting access to the fluid which in a few minutes would be injected into the blood of the human beings now assembling. The system with which the whole thing is arranged and carried out indicates the most minute and scientific attention to detail. No loophole is left for danger to creep in, and here an example of caution is laid down that should be followed in all other human inoculations. No accidental virus must be allowed to interfere with the perfectly studied progress of events. It is curious to consider that the original venom of the mad dog should be thus intercepted and neutralised by a graduated virus which in its strongest form is even more virulent than the original virus of the mad dog; and that it can be so introduced into the blood that human beings can live, and not even suffer, with all this poison in them! These assistants and all the employés are previously rendered immune by inoculations before they are allowed to engage in the work.

Stepping back into the passage once more, I found Madame Pasteur talking to a poor woman who had brought her little girl to be inoculated. She whispered to me it was too late, nothing could be done; fever had developed the night before, and the child was, even then, gazing up at us with fever in her eyes.

In the large reception-room people were arriving rapidly, people of every degree and in every stage of the treatment. The daily average is about eighty; six of these this morning were English, one or two having come from India. All are treated alike and free of charge. One poor little workhouse girl had been brought all the way from Ireland by the lady who accompanied her, but as she had been bitten through thick woollen clothes it was considered there was no danger, and no necessity for the treatment. After seeing a whole family of peasants inoculated who had been badly bitten on the face and hands, we pursued our way upstairs to see what was going on in the laboratories above.

In the very first laboratory we entered we were shown a glass phial containing a number of beautiful crystals with clear-cut facets like diamonds. Now, these crystals had not been taken from the bowels of the earth, but they had been produced artificially through invisible agency in the most simple and natural way. A common domestic onion was left to itself, a prey to the organisms or moulds of the air at a temperature suitable to their development, and lo! through the action of these little chemists the material, or part of the material, of that onion was transformed into these pure crystals. But those were not the only crystals produced by microbes, for we were shown others which we were politely invited to taste, and after some encouragement did taste and found the flavour delightful, being that of pure lemon. Now, there were no lemon trees growing within miles, yet here was fresh lemon grown in a cupboard amidst the terrible paraphernalia of a chemical laboratory! But again the method was very simple;

just a little sugar and water in a glass phial inoculated with some fungoid growth and placed in a culture chamber at 27° C., and in three weeks these lemon crystals were found lying at the bottom of the flask. This discovery of Pottevin's has already led to the formation of a large company in Paris for the manufacture of lemonade by this process.

Now in the scientific world it has been said that in the crystal lay 'the mystery and miracle of vitality,' Pasteur maintaining that here a sharp line of demarcation existed between organic and inorganic nature, while Professor Tyndall and other chemists were of opinion that the barriers had been overcome and that all things in Nature were united in one unbroken chain. Here, then, we seemed to be in the very act of picking up the links which brought the organic and inorganic together, the visible and invisible world into unison.

Passing into another laboratory, we found Metchnikoff studying the life history of bacteria when in the blood of man or animals. He showed us, under the microscope and in drawings, the white blood cells (which are always present with the red) in the act of absorbing pathogenic bacteria and digesting them at leisure, much as the oyster does with the bacilli of typhoid fever, which it can digest and get rid of in a week, if there are no more to follow. M. Roux, in the opposite laboratory, was giving his mind to serums, having already with others worked out and established the antitoxin which is now so much used in diphtheria. It was deeply interesting to note the enormous amount of brain power working at every point under the same roof to penetrate the mystery of disease and the mechanism of immunity. In some cases the living organisms of disease may be seen at work by placing a drop of infected blood under the microscope, and for such cases various methods of treatment have been found which destroy the organisms without killing the patient. But in other cases where no organisms are found in the blood the mystery is increased, and the difficulty of treatment is proportionately enhanced, for the symptoms of disease are actively present, and the physician has to deal with them at the bedside. For instance, in such deadly diseases as tetanus and diphtheria the living organisms do not enter the circulation, but stop short at the point of inoculation, and send through the blood the invisible poison they have the power to elaborate. Now, it was found in the course of these researches that the blood serum of rabbits which had been rendered immune against tetanus and diphtheria had no power to destroy or to retard the growth of the bacilli which caused these diseases at the point of inoculation, but it possessed the power of neutralising the poison they manufactured and sent through the blood. In short, the blood serum of the immunised rabbit was found to be an antidote to the poison, but not a destroyer of the living bacteria. But to this I shall refer later.

The savants whom I found in the midst of their work took the

opportunity of expressing the deep interest they felt in the experiments of their late colleagues, Yersin and Haffkine, with the plague serum and cholera vaccine in India. They seemed to be in touch with all the researches going on in every part of the world. One of the great advantages of a central school like this is that it brings all the workers in similar schools together, thus throwing a concentration of light on one subject till it is thoroughly thrashed out and developed. It is, in fact, a vast brotherhood working in the cause of humanity.

Returning home next day across the narrow streak which divides our proud little isle from the continent, the ease with which scientific researches are conducted on the one side of the Channel compared to the difficulties on the other could not fail to strike my mind. There the Pasteur Institute was erected as a thank-offering and tribute of respect to the founder of this new school, through the contributions of all nations save ours. Through an enlightened appreciation of the work being done, this living monument to Pasteur is perpetually being fed with votive offerings which pass through the grindstone of science, to come back, in various shapes, to the human race enormously increased in value. In common with many other individuals who contributed, the Comte de l'Aubesppin gave 1,600*l.*, while Madame Hirsch has recently given 2,000,000 francs (80,000*l.*). Another lady has founded four scholarships of 4,000 francs, or 160*l.*, each, and the town of Paris and Conseil Général de la Seine are instituting others. Then the French Government, encouraged by public opinion, contributes 1,200*l.* a year, which is paid by the Minister of Agriculture, who thereby enjoys the perpetual right to a place for a pupil sent from the Ecole Normale. This Government pupil receives a salary of 2,800 francs (112*l.*) a year, which is paid by the Minister of Instruction, who also contributes towards the salary of two *chefs de laboratoire*, each receiving 4,000 francs (160*l.*) a year, out of the fund for the 'Hautes Etudes.' Thus, abroad, science glides along under the happy auspices of enlightened public opinion, aided by the National Exchequer, while in England public opinion, being opaque to the advantages, fetters the hands that would help, and holds down this branch of science under the ban of unreasoning disapprobation.

The result of this difference between the two nations was brought home to us in a somewhat embarrassing way not long ago, through a little correspondence which took place between M. le Clercq, the president of the French Shorthorn Society, and Lord Brougham and Vaux, the president of the English Shorthorn Society. It seems that the French Government, profiting by their subsidies to the Pasteur Institute, have decreed that 'all imported bovine stock shall be tested at the frontier, and if they react unfavourably to tuberculin, that they must be immediately slaughtered or returned to the country

whence they come.' Accordingly, when two important bulls had been purchased in England by French breeders (one being 'Nonsuch,' the champion of last year's Royal Show), and were tested according to law on the frontier, they were both found to be tuberculous, and therefore unfit for breeding purposes. 'You will understand,' wrote M. le Clercq to his lordship, 'our unfortunate position and the cruel loss to our Society, because if our colleagues will not give us the assurance that their stock is free from tuberculosis, our subsidies will be withdrawn by the French Government, and consequently no more English purchases will be made.'

There is a calm dignity about this rebuke; and not a word to suggest that we do not enjoy the same means of testing cattle for disease that they have. In circumstances such as these it is not difficult to see how impossible it will be for us to meet the requirements of more advanced nations unless our Government also gives facilities to enable us to carry out the necessary conditions, for without the means of learning it is not easy, or even possible, to teach.

We are much in the position now, so far as the teaching of this new science goes, that we were in fifty years ago, when the public were horrified with the stories of body-snatching which ended in the trial of Burke and Hare. How was it possible, argued the professors of human anatomy, to qualify the students for their future responsibilities towards the public, without teaching them the structures of the human body? But it required the horrors of a public scandal to compel the Government to inquire into the existing state of things, and afford the medical schools the legitimate means of acquiring and imparting the necessary knowledge in the open light of day.

Ten years ago, when Pasteur's researches had already brought untold blessings to France, and had shed their light over Great Britain and all other countries, the first public laboratory for bacterial research was just beginning to be established in England, at King's College, at the private expense of the professor who has presided over it ever since. True, Sir Joseph (now Lord) Lister had introduced the antiseptic methods of surgery which were the outcome of Pasteur's studies on the micro-organisms of the air, &c., but Lister, in carrying out his early researches, had always to go abroad to obtain the necessary material. Meanwhile he had many disciples in this country who could neither afford to go abroad to study, nor find any school advanced enough in which to pursue the study at home.

Accordingly it was literally underground I had to burrow, when I was taken to see the only laboratory in London doing useful, though limited, work a decade ago, and just before the completion of the present one at King's College. It was strange after visiting Pasteur's laboratory, with its many tributaries in and out of Paris, to descend

into the humble basement of an ordinary private dwelling-house to find similar work going on there. There was a sense of secrecy in the atmosphere, as if the work intended for the good of humanity were conducted under the shadow of that dread persecution which so often stalks in the wake of ignorance, till the day of enlightenment comes. Above our heads was reared a noble pile of modern mansions, on every floor of which resided a family in peaceful unconsciousness of the arsenal of disease down below. It struck my feminine mind that the cook must have had a trying time of it, for I found that half of the kitchen, the whole of the scullery, and the entire pantry were given up to disease cultures in every stage of progress, while the wine-cellar, totally innocent of wine, made an excellent dark and heated culture chamber. Observing a dish of milk on the table, I inquired of my friend if that were meant for his own consumption. 'Oh, no,' he casually remarked, 'that is sown with typhoid fever, and is under observation.'

It may be consoling to the public to know that the only person who suffered at all from these dangers was the medical man himself, who lay for weeks very near unto death, a victim to his researches under difficulties. All this science in the wine-cellar has long since been given up, and the victim of enthusiasm is now in the forefront of his profession, teaching others, and giving the benefit of his experience to innumerable patients who little know how his special knowledge and skill were acquired. Since then I have found him working in the laboratory at King's College, the first established in London for the teaching of students, and available for the investigations of Lister and other men in surgical and medical practice.

Since then the Royal Colleges of Physicians and Surgeons have opened a research laboratory at the Examination Hall, and every here and there laboratories have sprung up in connection with medical schools and universities, but rarely without objections on the part of the public being raised, and every obstacle to research being thrown in the way. Now let us consider what this antagonism means. It means that these are efforts in a right direction, and distinctly intended for the good of the human race, but owing to the opposition of the ignorant they prove so inadequate to the requirements of the age, that we have to stand aside and allow other nations to do the work, while we either suffer the consequences, or reap the benefit, as the case may be. For instance, as to the benefits, we are distinctly a beer and spirit drinking nation, but outside scientific circles we are untroubled with the reflection that all the waste and difficulties we encountered in the manufacture of beer and spirits a few years ago have been entirely overcome owing to the laboratory researches of Pasteur. The beer no longer goes sour before it has matured, without our knowing the reason why. Its manufacture is no longer limited to the autumn, but can be continued throughout

the year. The result to the country is enormously increased revenues from this source, and as an indirect outcome the people are enjoying the advantages of free technical education, through the county councils, the funds for which, amounting to over 700,000*l.* a year, are provided by the Government out of the surplus duty on beer and spirits.

Again, we hear no more about the silkworm disease, which five-and-twenty years ago threatened to devastate the lands of the golden cocoon, until Pasteur was induced to take the matter up, and, after two years of arduous study, discovered the remedy now universally applied. But it never occurs to us to think why silk is so abundant and so cheap.

Let our minds wander to those cruel battlefields which afflict us to think of, and the comforting thought comes to our relief that even the most severely wounded have now a chance of life they never had before. If we push our reflections a little further we shall find this is due to the knowledge of 'those lurking principles of death' which has sprung from the laboratories of other nations. True, it was Lister who first grasped the principle and applied the remedy to surgery, but the knowledge of the living cause of disease originated abroad, and, as I have already said, was elaborated by Lister on foreign soil.

When our Government officials, postmen and policemen, and people generally, are bitten by mad dogs, we thankfully send them to Paris to be inoculated with the anti-rabic virus at the expense of the Pasteur Institute. A fund at the Mansion House exists for this purpose, but we have never contributed as other nations have to the erection, endowment, or expenses of that great school.

In Australia it was Pasteur's assistants who discovered the Cumberland disease to be the same as anthrax, and who have established the protective vaccine in that country.

At this moment Yersin and Haffkine are succeeding in inoculating the people of our Indian Empire against the plague with their defensive serum, and Germany has sent a scientific commission, consisting of her most distinguished men, to Bombay to study the disease. Our illustrated papers, without the slightest jealousy, have depicted the group established in a well-appointed laboratory.

To Pasteur we owe the inestimable knowledge of what a ferment means, not only within the brewer's vat, but within the blood and tissues of men and animals. What was dead to us before now lives, what was unseen is now visible, what was intangible can now be dealt with. The result is that these studies, having already conquered new worlds, open up vistas of endless worlds yet to conquer. But are we doomed to leave all these possible conquests to other nations for ever? or has the time come when we can hope to join the great brotherhood, and work shoulder to shoulder in the cause of humanity?

Let us survey the land of our birth and see what our prospects are towards this scientific unity of nations.

Through the energy of some of our leading men, what is known as the British School of Preventive Medicine was established in London a few years ago. People pass the door every day on their way to the British Museum, but there is nothing to distinguish it from the ordinary houses in the street. Yet within this very ordinary house lies that which has the power to save mothers from the life-long agony of seeing their children die of diphtheria, and also that which may save husbands from the misery of seeing their young wives sacrificed to certain forms of puerperal fever, while all the research is going on which is necessary to accomplish these ends. We are getting accustomed to hear of serums, and we shall soon take it as a matter of course that we can send round to the nearest chemist for a bottle of antitoxin for this complaint or that; but it is not within the power of the uninformed mind to conceive the nature of the work required to produce such remedies.

In connection with this ordinary-looking house there is what the director is pleased to call a 'farm' a few miles out of town; but the farm is a villa residence on the roadside, with a little paddock at the back where structures have been erected for the necessary horses, and the laboratory. In the first place it is interesting to observe that the farm is kept in the most perfect sanitary condition, and that the horses are all tested for glanders with an antitoxin called mallein, and for tuberculosis with tuberculin, before they are subjected to the treatment necessary to make them immune against other diseases. This *testing*, and the preparation of the tests, involve the most advanced scientific knowledge, and is what the French Government expects of us before sending the animals they have bought into France. In the farm laboratory, which is under the charge of Dr. Bullock and an assistant, you may see diphtheria growing visibly before your eyes. In the flask containing it is a little soup, which was quite clear yesterday before it was inoculated with a trace of diphtheria culture taken from another flask. Now it is clouded, and on the surface a morbid growth is settling, painfully resembling the growth that may be seen in the throat of a patient suffering from that cruel disease. This particular specimen of the diphtheria bacillus had gone through hundreds of generations, passing from flask to flask, without losing any of its virulence. Two years before it had been taken from the throat of a child in Norway, sent to the Pasteur Institute, and from there passed on to us. The culture is grown for seven or ten days in the flask at a temperature of 37° C. It is then filtered through a Chamberland filter and its strength tested.

The horses, which are well fed and kept in excellent condition, are now inoculated with small and gradually increasing doses of this

active diphtheria poison, until they are rendered perfectly immune. During this process they seem more bent on the bits of sugar they are getting than disturbed by the prick of the syringe. At first the temperature slightly rises, but after twenty-four hours all symptoms are gone. After three, four, or five months the maximum anti-toxicity is reached. A little of the blood of the horse is now drawn into a glass flagon, carefully protected from the possibility of inimical germs reaching it. The red constituents of the blood fall to the bottom of the flagon, leaving a clear fluid above; this is the anti-toxic serum, the antidote for the poison. But it is not completed yet, for it has to be tested to see that its value comes up to the standard which has been established by the German Government. This done, a number of very small blue bottles are withdrawn from the sterilising chamber and filled with the precious fluid, every bottle being labelled and marked with the strength of the dose. They are then forwarded to the laboratory in Great Russell Street, and are ready for the hospitals and for use in private practice.

This work is of such paramount importance that all the scientific men engaged in it are agreed as to the necessity for Government jurisdiction in the preparation of serums. That coming to our country from some quarters is frequently found to be below the accepted standard, hence likely to fail at the critical moment.

The method I have just described applies equally to the tetanus serum, only the process is slower, owing to the horse being more susceptible to this disease.

To prepare an antitoxin for the treatment of septic diseases, living cultures of the micro-organism known as the *Streptococcus pyogenes* are used. The maximum of virulence is obtained by passage from rabbit to rabbit, and the serum is used for erysipelas, some forms of puerperal fever, blood poisoning, &c. Both in France and in this country good results have followed the treatment in puerperal fever.

Thanks to the goodwill of a humane individual, Mr. Berridge by name, who left a large sum of money to be devoted to the spread of sanitary knowledge, a portion of this benefaction has afforded the means for carrying out this work for the last few years, in a small way, pending the erection of a more suitable building. A site for this has been found on the Thames Embankment, and there the structure may now be seen. It is proposed that this should be a school of hygiene as well as a school of preventive medicine, but it is not considered either desirable or necessary to carry on anti-rabic inoculations here, owing to the easy proximity of Paris. People, however, would be able to have the question definitely decided in this laboratory as to whether the dog was really mad that bit them. This is a point at once affecting the happiness and the purse of those who are bitten. It is known that 'dogs suffer from symptoms simu-

lating those of rabies; and formerly, when human beings were bitten, it was impossible in some cases to determine whether the dog had been suffering from rabies or not. We are indebted to Pasteur for the only trustworthy test which can be applied; and we are now in a position, when a human being is bitten by a dog supposed to be, but not really, rabid, to remove all cause for anxiety, which would otherwise remain for months or even years.¹ All that is required is to have the dog killed and the head sent to the research laboratory, where a rabbit would at once be inoculated with a portion of the brain. The death or life of the rabbit in a few days would settle the question of going over to Paris for the anti-rabic treatment or resting in peace at home. With a test laboratory in India many of the people now sent on to Paris in anxiety and haste might be spared a long and costly journey. Again, instead of our Government vaccine station occupying the ground floor of a poor house, in a poor street, it would be better to annex it to this new School of Preventive Medicine, with a suitable subsidy from the Government. Here also questions affecting not only the health of human beings and animals, but the industrial and agricultural prosperity of the people, will be scientifically studied, and brought to a practical conclusion. It further holds out a prospect that animals intended for breeding purposes in our own and other countries may be tested at home, and this with serums or vaccines sent forth from our own central laboratory made by the experts of our own country. If this can only be done in a large national way, and certificates of health after testing could ensure sound meat at the market-place, and wholesome milk in our homes, the boon to the community would be quite as great as vaccination against smallpox is at present. It is due to the Berridge fund that a start has now been made, and it is hoped that enlightened public opinion will enable it to go on.

At the end of the nineteenth century it is deplorable to think that as a nation we are still much in the same position with regard to this branch of science as that in which Sir Isaac Newton found himself when he said, 'I have been but a child playing on the seashore, now finding some pebble rather more agreeably variegated than another, while the immense ocean of Truth extends itself unexplored before me.'

ELIZA PRIESTLEY.

¹ Crookshank's *Bacteriology*.