tioned in our columns (BRITISH MEDICAL JOURNAL, 1900, vol. ii, p. 667) that he used the double cyanide of zinc and mercury with which Lord Lister had supplied him in powder, but more conveniently in a paste made with a watery solution of carbolic acid. Mr. Cheate states that it "proved most satisfactory." Mr. Watson Cheyne has also described this method of treating gunshot wounds (BRITISH MEDICAL JOURNAL, 1900, vol. i, p. 1193).—ED. B.M.J.]

An Address

ON

PASTEUR AND LISTER.*

By D. BERRY HART, M.D., F.R.C.P. EDIN.,

Gynaecologist, Royal Infirmary, Edinburgh: Lecturer on Midwifery, School of the Royal Colleges, Edinburgh.

At the opening of a session, what we all need is encouragement—something to give us the initial impetus that will keep our energies going until the welcome goal of the end of the term is reached. That great master of English, Newman, has said, "Persons influence us, voices melt us, books subdue us, deeds inflame us." What persons, what deeds can we at present consider to stir up our latent energies?

The greatest discovery of the last century has undoubtedly been that relating to the nature and prevention of septic disease. With the foundation and building up of this knowledge two great names are associated—Pasteur and Lister. At Pasteur's jubilee, held in Paris in 1892, the meeting of these two great scientists gave practical expression to the fact, and, as Pasteur's biographer puts it, as only a Frenchman can: "When Pasteur rose to embrace Lister, the sight of those two men gave the impression of a brotherhood of science labouring to diminish the sorrows of humanity." Let us briefly, then, consider how this great discovery arose and some of the lessons to us all from its evolution.

PASTEUR'S YOUTH.

Louis Pasteur was born at Dôle on December 27th, 1822. His parents were of comparatively humble rank, but of sterling worth. To his father—a tanner and an old Peninsular hero of Napoleon the Great—he owed his tenacity and seriousness. From his mother he got imagination, activity, enthusiasm. He had an excellent literary and scientific training at Besançon, but, while he passed before the Dijon faculty satisfactorily, he was put down as only "mediocre in chemistry." His study in Paris under Dumas, the famous chemist, inspired him, however, and he took much higher places in his classes and examinations afterwards. There are, however, significant facts that show his powers and energy; one of these is his preparing 60 grams of phosphorus from bones, as the lecturer had not had time to go into the process sufficiently. This took him seventeen hours' consecutive work to accomplish.

CRYSTALLOGRAPHY.

One of his first pieces of original work was that in relation to crystallography. I merely note it here, as it shows early Pasteur's powers and method. It had been observed that two salts of soda—the tartrate and paratartrate—although of apparently similar crystalline form and chemical constitution, behaved differently to polarized light. No explanation had been given of this by such authorities as Mitscherlich, but Pasteur showed for the first time that it was due to a peculiar faceting on one side of the crystals in the tartrate—that is, they were asymmetrical—while in the paratartrate they were symmetric. In the first, one got, therefore, the deviation of the plane of polarized light to the right, while in the paratartrate the symmetric arrangement was inert to polarized light. Pasteur gave, indeed, a triumphant demonstration as he separated the paratartrate crystals into right and left groups, and showed that the one turned the plane of polariza-

tion to the right, the other to the left. This Biot confirmed; a solution of both was inert.

Carlyle has said of a famous French historian, that you did not dig long in his work before you came to water. With Pasteur it was otherwise; he thought out his investigations to the "bed rock," and built on it a stable research. He expressed his delight at this discovery in almost Archimedean fashion, and, as the paratartronic acid (racemic acid) was seldom obtained then, he journeyed to Germany, Trieste, and finally settled that it was sometimes found in the mother liquor. He also made it artificially, as a triumphant telegram to his father announced.

We see here, early in his career, Pasteur's method of research; how an anomaly fascinated him, how with unbiased eye he collected his facts, how his imagination furnished him with a theory or theories which he rigorously tested, and how finally he ran the anomaly to earth. All this was done with immense enthusiasm and with a defence of his work when assailed, as vigorous as it was successful. Pasteur tried to penetrate further into molecular mysteries, but gave it up. He laid the foundation, however, for some very beautiful work by future observers.

FERMENTATION.

We now come to the fundamental part of Pasteur's work, that on which his magnificent researches were built—his studies on fermentation and spontaneous generation. Almost all his subsequent discoveries were the outcome of these researches or ran on similar lines. Of course, I merely touch on these subjects, not critically, or in detail, but solely to illustrate the lessons they afford us all. When Pasteur was appointed to Lille he was in the centre of the distillery district, and naturally the question of fermentation came up. The dominant view as to fermentation was that of Liebig, that it was a "change in organic fluids and tissues set in motion by the access of oxygen or of bodies in a state of decomposition," practically this was a theory, a purely chemical phenomenon, not a vital one. The presence of organisms he considered accidental. Pasteur, however, showed, with others, that the yeast plant was not a secondary formation in alcoholic fermentation, but the prime cause. By growing yeast in a solution of pure sugar, with no albuminoids but only ammonium salts to give nitrogen, Pasteur got alcohol and carbonic acid, thus showing that the yeast itself was the actual agent in the fermentation, and he thus confirmed and proved the original work of Cagniard, Latour, and Schwann, which had been obscured by Helmholtz, Liebig, and others. Similar evidence he provided for other fermentations, and thus what had been obscure and darkened by words now stood forth clear and distinct.

The exact facts about lactic acid fermentation were further made out by Lister in a series of very beautiful researches. One of Lister's points has always seemed to me very significant to medical men. Lister found that milk had no "inherent tendency to undergo lactic acid fermentation," but that it underwent it very readily in a dairy where, of course, the bacterium lactis flourished. This must be kept in mind in regard to our hospitals. The greatest precautions must be taken lest we grow in them specific organisms causing sepsis. This, of course, is done.

SPONTANEOUS GENERATION.

Pasteur was, naturally, next led to investigate the subject of spontaneous generation. To us, to whom the non-existence of spontaneous generation is an axiom, it seems difficult to realize that it was disputed. The history of the controversy is extensive, but Pasteur is generally considered to have dealt the death blow to this specious theory. Micro-organisms—or, to use Pasteur's favourite word, microbes—will not develop spontaneously in a fluid, after that fluid has been sterilized by careful boiling, if air either has not access or is filtered of its impurities. Thus the various fermentations are not spontaneous, but the specific organisms causing them are introduced from without, from the atmosphere or from unpurified surroundings. The fight here was a prolonged and bitter one. It was valuable, however, to have this severe criticism. For instance, it came out that some organic infusions needed prolonged heating at a temperature above boiling point to sterilize them. It also showed that at different places the contaminating power of air varied.

* A report with some omissions of an address delivered at the opening of the winter session, 1902, of the Medical Faculty of the University College of South Wales and Monmouthshire, Cardiff.

The first point is of value to the surgeon, especially when he wishes sterile catgut for operating work; and, indeed, the question of an absorbable, trustworthy, sterile suture—catgut, for instance—has yet to be solved.

It would be out of place here to give details as to Pasteur's work on spontaneous generation, but I cannot refrain from quoting this simple and beautiful passage from one of his lectures given at the Sorbonne. He said:

Here is an infusion of organic matter as limpid as distilled water and extremely alterable. It has been prepared to day. To-morrow it will contain animalculae, little infusories, or flakes of mouldiness. I place a portion of that infusion into a flask with a long neck like this one. Suppose I heat the liquid and leave it to cool. After a few days, mouldiness or animalculae will develop in the liquid. By boiling I destroyed any germs contained in the liquid or against the glass; but that infusion being again in contact with air, it becomes altered, as all infusions do. Now suppose I repeat this experiment, but that before boiling the liquid I draw (by means of an enameller's lamp) the neck of the flask into a point, leaving, however, its extremity open. This being done I boil the liquid in the flask and leave it to cool. Now, the liquid of this second flask will remain pure not only two days, a month, a year, but three or four years—for the experiment I am telling you about is already four years old—and the liquid remains as limpid as distilled water. What difference is there, then, between those two vases? They contain the same liquid, they both contain air, both are open! Why does one decay and the other remain pure? The only difference between them is this: in the first case the dusts suspended in air and their germs can fall into the neck of the flask and arrive into contact with the liquid, where they find appropriate food and develop; thence microscopic beings. In the second flask, on the contrary, it is impossible, or at least extremely difficult, unless air is violently shaken, that dusts suspended in air should enter the vase; they fall on its curved neck. When air goes in and out of the vase, through diffusions or variations of temperature, the latter never being sudden, the air comes in slowly enough to drop the dusts and the germs that it carries, at the opening of the neck or in the first curve.

This experiment is full of instruction, for this must be noted that everything in air save its dusts can easily enter the soil and come into contact with the liquid—imagine what you choose in the air—electricity, magnetism, ozone, unknown forces even, all can reach the infusion. Only one thing cannot enter easily, and that is dust, suspended in air. And the proof of this is that if I shake the vase violently two or three times in a few days it contains animalculae or mouldiness. Why? Because air has come in violently enough to carry dust with it, and therefore, gentlemen, I could point to that liquid and say to you, "I have taken my drop of water from the immensity of creation, and I have taken it full of the elements appropriated to the development of inferior beings. And I wait, I watch, I question it, begging it to recommence for me the beautiful spectacle of the first creation. But it is dumb, because I have kept it from the only thing man cannot produce, from the germs which float in the air, from life, for life is a germ and a germ is life. Never will the doctrine of spontaneous generation recover from the mortal blow of this simple experiment."

Spontaneous generation non-existent, fermentation due to outside specific contamination, could these great facts have any bearing on the putrefaction of wounds? In order to silence his adversaries, Pouchet and others, Pasteur proposed arbitration—the favourite device now in labour disputes—before the Academy of Sciences. Pasteur alone appeared, and the arbitrators decided in his favour, as his yeast infusions remained sterile. His adversaries would have employed hay infusion, and as this required a higher temperature to sterilize than was then obtainable, the result might not have been in Pasteur's favour at first. The year 1870 was one of anguish to Pasteur, and he protested vigorously, if not always wisely, against his country's humiliation. Yet the horrors of the septic infection in the ambulances of the campaign, where fetor and septicaemia seemed endemic, gave to French surgeons and scientists an object lesson on a huge scale of the dangers of surgery in war, and should have suggested to surgeons the probability that a development of Pasteur's work would help them. Yet with the exception of Guérin's and Lemaire's inconclusive work, nothing was really accomplished in this direction.

LISTER'S APPLICATION OF THE THEORY OF FERMENTATION.

Fortunately for suffering mankind another great mind, Lister's, saw the significance of Pasteur's researches and applied them to surgical treatment.

In his now historical papers on the Treatment of Compound Fracture Lister showed how remarkable it was that cases of

simple fracture of bone or of lung injury from ribs escaped the pyaemia of the compound forms of fracture. The main difference between the simple and compound fractures is that the broken bone in the former fracture does not communicate with the air and unpurified skin; in the latter it does; the air gaining access to the tissue injured by the rib was filtered by the minute vesicles of the lung. Lister goes on to say:

Turning now to the question how the atmosphere produces decomposition of organic substances, we find that a flood of light has been thrown upon this most important subject by the philosophic researches of M. Pasteur, who has demonstrated by thoroughly convincing evidence that it is not to its oxygen, or to any of its gaseous constituents, that the air owes this property, but to minute particles suspended in it.

Since 1867, however, we have travelled further than this, and the specific organisms causing various septic diseases have been isolated; the diseases themselves have been artificially produced by these organisms, and, best of all, vaccines antitoxins, or antidotes have been obtained, enabling us to protect against certain diseases, or combat them successfully in their earliest stages.

Lister started, then, with the idea of destroying the activity of these "germs" in the wound surroundings by an antiseptic, and carbolic acid was the one he selected. I need not detail how Lister passed from crude methods to his fully developed antiseptic system or "Listerism," but may indicate what the latter really was. Lister's aim was to purify the area operated on and all that touched the part to be operated on—hands, sponges, instrument—and this was effected by the use of carbolic lotion in varying strengths. The wound made was dressed with gauze impregnated with carbolic, and while the operation was going on, and at any time afterwards when the wound was exposed to air, a spray of carbolic lotion was played over and on it. You do not see this now in our hospitals, but in my student days, when I had the great privilege of studying and working in Lister's service, it was the routine where the operation was performed on an unbroken surface.

Listerism made an undreamt-of revolution in surgical results, and sepsis ceased in a great measure to be the surgeon's bane. What a terrible reality sepsis was is shown by such a statement as this by Velpeau:

A pinprick is a door open to death. That open door widened before the smallest operation; the lancing of an abscess or a whitlow had such serious consequences that surgeons hesitated before the slightest use of the bistoury.

You may ask, however, why was this special system modified? For many reasons. The spray was ultimately found superfluous, although some good men doubt that; the disinfection of the area to be operated on, and of the surgeon's hands, was shown to be a more difficult thing than was at that time thought. Carbolic lotion was found to require greater time to effect its purpose, and thus a system has now developed from Listerism termed asepsis in operating. Practically we combine certain features of Listerism with our aseptic methods. For instruments, the most effective method of sterilization has been proved to be boiling with ordinary washing soda; for all gauze that may touch the wound or for silk sutures used in it, moist steam is employed under pressure, while for hands and operation area we rely on a thorough and prolonged cleansing with antiseptics, whose familiar names I need not recall to you. We thus secure the "clean touch" for our operative work.

The results of this method as to life and comfort are surpassingly good, and deaths from sepsis have been diminished to an incredible extent.

You see, then, how two great minds evolved a method of treatment which has saved and will save an incalculable number of lives. Could not the simpler aseptic methods have been evolved first? Nature's evolution is from the simple to the complicated, man's from the complicated to the simple—from complicated antiseptics to simpler asepsis—as from wire telegraphy to wireless.

Asepsis was in Listerism, and in his teaching at Edinburgh many years ago Lister always insisted on this.¹ When one looks back on Pasteur's work, however, we note in his fermentation and spontaneous generation methods the principles of asepsis—cleanliness of hands, disinfection of

instruments by the lamp flame, boiling of flasks, sterilization of cotton plugs.

LISTER AS A PHYSIOLOGIST AND BACTERIOLOGIST.

So much briefly for the work in respect of these great men; what as to the men themselves? Lister is fortunately with us still and it is not for me to praise him.

One point, however, I must allude to, and that is that Lister was a great physiologist and pioneer bacteriologist before and after he took up surgery. His father also was an eminent investigator on the structure of the microscope, and here again we see scientific heredity. Here, then, we see what scientific knowledge, if properly applied, means to surgical practice. As an old student, I may point out also that no teacher in my opinion has ever exerted such an influence for good on his pupils as Lister did. His scientific acumen and knowledge, his power of work, honesty of purpose, zeal for science and self-sacrifice for his patient's sake made an indelible impression for good on his clerks and dressers. No chief was more revered, and that is but an index of the honour that will for ever attach to the man who robbed surgery of its greatest terror.

THE SCIENTIFIC METHOD.

Pasteur's works one knows; but of the man I can merely say "*Vidi tantum*."

In what did Pasteur's power lie? First, of course, he had the gift of genius; that cannot be explained or dissected. His training was excellent. He was a first-rate chemist and physicist. Let every medical student keep this in mind as he perhaps groans over his preliminary scientific work. These subjects are of prime importance in the medical groundwork and in medical investigation, and will prove more so as time goes on. In warfare we know what it is to have guns that fall short of the enemy, and in many researches ignorance of chemistry is fatal, as it means attacking a problem without the necessary means of investigation. From his father Pasteur had tenacity, as I have said; from his mother, imagination. Pasteur was an artist, and probably would have been a great artist had science not enthralled him. France, the home of art, need not grudge science her conquest. No man can be a great observer or discoverer unless he has imagination under control. No man will be a great discoverer whose imagination is allowed to run riot. Pasteur theorized in abundance, but he controlled it by observation, and abandoned theory if facts were against it. Pasteur's own powers of work were enormous, and "work" was his unflinching advice to the young. Yet he overdid it, and his early paralytic breakdown, although he recovered, was a most serious matter.

His earnestness was equalled by his simplicity. When he came on the platform at the London International Medical Congress in 1881, and heard the thunders of applause, he remarked that Royalty must be arriving. It was a Prince in Science, however, that the audience was honouring.

PASTEUR AND HYDROPHOBIA.

Pasteur's greatest work has always seemed to me to be his research on hydrophobia. Indeed, it resembles inspiration more than genius. One circumstance connected with it will touch keenly every medical man. The time came when his research had to be tested on actual human cases. He had rendered dogs immune, and had administered his antirabic virus successfully to the lower animals suffering from rabies; but the responsibility of treating man was immense. On July 6th, 1885, Pasteur saw the little Alsatian boy, Meister, who had been dreadfully bitten by a rabid dog, subjected him to his inoculations twelve times, and saved him from the terrible disease. His anxiety was, however, tremendous, and after the last inoculation he spent a terrible night of insomnia; "in these slow, dark hours of hours of night, when all vision is distorted, losing sight of the accumulation of experiments which guaranteed his success, he imagined that the little boy would die."

Pasteur was an impassioned controversialist—in this a contrast to Lister, who has entered little into public argument. When, for instance, a German scientist spoke of the crystals of the tartrate as hemihedral on the left side, whereas Pasteur had spoken of them as hemihedral on the right side, it was evidently a mere case of holding the crystal another way.

But some enemies spoke of this as if Pasteur were wrong after all. It was really not worth noticing, but Pasteur indignantly demanded a special meeting of the Philomathic Society to discuss it. "He superintended the making of a complete wooden set of the crystalline forms of tartrates" on a very large scale, and appropriately coloured. On these he demonstrated his views in the most impassioned manner, his friend Duclaux almost anticipating that he would finally hurl his models at his adversaries' heads.

THE FACULTY OF "NOTICING."

One instance illustrates his faculty of "noticing." One day when examining a fermenting liquid (butyric) he noticed that the "bacilli" were motionless at the edge of the cover-glass, active in its centre. This would not have struck an ordinary observer, but it struck Pasteur. He asked himself, "Is the oxygen killing the peripheral bacilli?" He passed oxygen through a flask of this fermenting liquid and stopped the fermentation. Thus he showed that some bacilli, termed anaërobic, could live and develop energy apart from the presence of oxygen.

THE RISKS OF EXPERIMENT.

His magnificent work on *Hydrophobia* was one of the greatest heroisms. There was a very distinct danger to life in dealing with these rabid animals. Then, as I have already stated, came the question of the great responsibility of treating human beings with his remedy. "I have not yet dared," he said, "to treat human beings after bites from rabid dogs, but the time is not far off, and I am much inclined to begin by myself, inoculating myself with rabies and then arresting the consequences, for I am beginning to feel very sure of my results." Yet Pasteur was bitterly attacked by some, his cure stated to be useless and in some cases dangerous. So far did this go that it wrung from him the mournful complaint, "I did not know I had so many enemies." This to the man who had risked his health and life to alleviate or abolish suffering in this world!

THE NATIONAL VALUE OF SCIENTIFIC RESEARCH.

Pasteur's work did not merely save life. In manufactures its influence was of the highest value. To brewers, silkworm cultivators, agriculturists, his researches were of incalculable monetary value, certainly running into millions. In average years in France the value of the cocoons produced reached 100,000,000 fr., while in 1863 and 1864 it fell to 24,000,000 fr., a loss of 76,000,000 fr.—that is, roughly, £3,000,000. By his researches in silkworm disease Pasteur brought back the old prosperity.

The value of scientific research to a municipality was well shown here by the work, as to a case of plague, done by Dr. Savage, the Lecturer on Bacteriology in the University. I have no doubt that still more good work will come from this department.

APPLICATION OF PASTEUR'S RESEARCHES TO MEDICINE AND SURGERY.

One point I may finally note: Pasteur was not a medical man. This was a real advantage. He had more time for science, approached medical questions without bias, and as much of his treatment—that of immunity and inoculation—was new, his researches, on the whole, were more valuable.

Pasteur was unable, however, to apply his researches to surgical treatment; but here Lister stepped in, and by his genius and his great physiological and surgical knowledge, crowned Pasteur's investigations with his imperishable work on *Antisepsis and Asepsis*.

Pasteur died on September 28th, 1895, and in him there passed away a man of colossal genius. May we all be inspired with his singleness of aim, his love of work, his devotion to the saving of human lives; and, above all, may we apply carefully in our routine work those methods for combatting sepsis which Pasteur and Lister evolved.

NOTE.

¹ Next the wound a piece of gauze was put below the superficial gauze dressing, and termed the "deep dressing." Lister used to point out that after the wound discharge (serous) had washed out the carbolic from the deep dressing, the wound could be considered "aseptic."