determine to honour the memory of the deceased with a garland which he shall receive who has done the most for the art and in the art of statuary. The beloved Master has often praised the smith as the author of their great success, and they finally decide to award the garland to him. "Well," answers the smith, "I consent. You are many, and among you are clever people. I am but a single man. You assert that I singly have been of service to many of you, and that many places teem with sculptors who decked the temples with divine statues, which, without the tools that I have given you, would have been very imperfectly fashioned. I must believe you; as I have never chiselled marble, and I accept thankfully what you award to me. But I myself should have given my vote to Praxiteles or Paionios."

THE BRADSHAW LECTURE ON BACTERIOLOGY IN ITS RELATIONS TO SURGERY.

Delivered at the Royal College of Surgeons, on Thursday,
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GENTLEMEN.—I propose in the lecture which you have this year done me the high honour of electing me to deliver in commemoration of Mr. Bradshaw, to place before you the knowledge which has been recently gained by the new science of bacteriology, in its relations to surgery. In beginning to work at the subject, I immediately found myself confronted with a difficulty which arose from the great confusion that at present exists in regard to nomenclature; and though I probably do great wrong to some of those who are now my auditors, I am convinced that many surgeons have only hazy and indistinct ideas in regard to the classification of these minute beings, and will not be ungrateful to me if I place before them a succinct account of the arrangement that is accepted provisionally by the best authorities in Germany and France, as well as in this country, and add a brief outline of the chief facts that are known in regard to their life history.

Truth, says Lord Bacon, is more easily educed from error than from confusion, and no better illustration could be adduced of the maxim than the advantages that are to be gained from even a provisional and incomplete arrangement of these minute organisms into genera and species. Botanists have divided plants into two great groups: phanerogamous plants, with more or less showy flowers and conspicuous organs of generation and fructification; and cryptogams, which propagate in a secret, inconspicuous, and mysterious method by spores. The cryptogams are again divided into those which have a stem and leaves like ferns, and those which produce flat expansions on or in which the spores grow, and which are termed thallophytes. The thallophytes were formerly divided into fungi, algae, and lichens, the broad distinctions between which were that the fungi were destitute of chlorophyll, contained much nitrogen in their composition, and lived on organic substances, whether dead or living, and in air; that algae contained chlorophyll and lived in water, building up their bodies from inorganic material; and, finally, that the lichens consisted of a mixture of cells, some containing, some destitute of, chlorophyll, nourishing themselves on inorganic substances, and usually living in air. Late researches by Schwendener and others have rather tended to show that the lichens are really algae which have been invaded by fungi; and, at all events, it has been found that neither lichens nor algae bear any very important relation to disease, and that those minute organisms which are really influential in the production of a very considerable number of the maladies incidental to man and animals, and especially those which are of an infectious or contagious nature, belong to the fungi. Now the fungi have been subdivided by Flügge—looking at them essentially from a hygienic, and not from a botanical, standpoint—into four groups: (1) the fungi proper; (2) the mycetoza; (3) the blastomycetes; and (4) the schizomycetes.

Many of the true fungi play an important part in the economy of

nature, and are of great importance to man in their industrial relations. To mention only two of them. The *Ustilago carbo* forms the black smut of wheat and other cereals, and *Tilletia caries* or bran forms a similar substance in the interior of the grain, and gives a fetid odour to it. *Peronospora infestans* is the fungus of the potato disease. *Botrytis bassiana* is the muscardine disease of the silkworm. *Uredo* or *æcidium* (of which *puccinia graminis* is an example) forms the red rust of wheat, which is perhaps one of the most important and interesting fungi, and the singular history of which in connection with the barberry, is now well known from De Bary's observations. Then come the *aspergilli*, interesting because some of them can grow in the bodies of warm-blooded animals, and are capable of producing attacks of pneumonia in man and animals. The spores of these fungi are everywhere so abundant that it is only requisite to expose a piece of black bread to the air for a short time, and then place it in a moist warm chamber, and one or other form of *aspergillus*, according to the temperature, to appear with certainty. The *erysiphe-oidium*, or mildews, are found in the grape disease, caused by *oidium tuckeri* and *oidium lactis*, which forms a white covering to milk, bread, and dung; and closely allied to these are the fungi causing the parasitic skin diseases known as favus, herpes tonsurans, and pityriasis versicolor. The mucors and penicillium complete the list, these being the most common of all. None of them are of particular importance to the surgeon, except perhaps to the army surgeon, to whom the quality of the food, and especially of the bread, supplied by the commissariat, is a subject of unflinching interest.

The *Mycetoza* may be passed over, as so little is known in regard to their relation to disease.

The *Blastomycetes* are represented by the yeasts and organised ferments which convert sugar into alcohol and carbonic acid, and the examination of which, in the hands of M. Pasteur, may be said to have led the way to all recent research on the subject of microbes.

From them we pass to the *Schizomycetes*, which have been differently grouped by different observers, and I here exhibit to you the classifications of Zopf and of Flügge, and also of Klein, whose excellent little work on Micro-organisms, just published, should be in everyone's hands. Klein divides the schizomycetes into micrococci, bacteria, bacilli, and spirilla, and each of these he subdivides into those that are septic, those that are zymogenic, those that are chromogenic, and those that are pathogenic. Septic microbes are those which excite, or at least accompany, the putrefaction of organic matters. Their action on proteids, as Hoppe-Seyler has pointed out, resembling digestion: the first products being peptones, then leucine, tyrosine, and the fatty acids; and, finally, indol, phenol, scatol, hydrogen sulphide, ammonia, carbonic acid, and water. From putrefying animal substances there may be obtained a material which is certainly not living, —for it can dialyse through a membrane,—but capable of exciting septicæmia when introduced into the healthy body of animals, a condition which must be carefully distinguished from pyæmia. Septic poisons produce an effect commensurate with the quantity of the poison introduced; if the quantity be small, only slight and transient effects are produced; if it be large, the effects are more severe, and vomiting, rigors, spasms, and collapse ending in death, may occur. *Post-mortem* examination shows congestion and hæmorrhage of the lungs, and intestinal mucous membrane. In pyæmia, on the other hand, a poisonous agent is also introduced into the system, but it so far differs from the poison of septicæmia that it appears to be living, and capable of multiplication, so that a very small quantity may prove fatal by the formation of numerous and widespread abscesses. It is possible, however, that, as Klein argues, large open wounds may become the seat of the multiplication of various organisms, which, by producing a septic poison, may produce septicæmia when absorbed in sufficient quantity.

Zymogenic Microbes.—The term zymogenic action is only another term for the induction of fermentation, and upon the whole of this subject a flood of light has been thrown by the labours of Pasteur. The chief forms are (1) the alcoholic, (2) the lactic, (3) the viscous, (4) the acetic, (5) the ammoniacal, (6) the butyric, and (7) the putrid fermentation. The agents are always microbes destitute of chlorophyll, and are generally anaerobic, obtaining the oxygen they require for growth and activity from the oxidised compounds in the liquid in which they grow. The micrococcus of urea and that of the phosphorescence of putrid meat and fish are, however, aerobic. The ammoniacal and the putrid fermentations are of the greatest interest to the surgeon. The former is exemplified in the action of the micrococcus ureæ and the bacillus ureæ in converting urea into ammonium carbonate. The micrococcus ureæ appears, when cultivated, in the form of minute spherical cells, either separate or united in diplococci, or in

tetrads or in chains. They do not fluidify gelatine. The development of the microbe is not interfered with by the alkalinity of the fluid, and it can continue when the proportion of ammonium carbonate is as much as 13 per cent. The most favourable temperature for its development is from 30° to 33° C. The bacillus uree is a short plump bacillus, with rounded poles about twice as long as wide. Growth only takes place on the surface, and like the micrococcus. Its action, as is now well known, is to decompose urea into ammonium carbonate with absorption of water. $\text{CO} \begin{cases} \text{NH}_2 \\ \text{NH}_2 \end{cases} + 2\text{H}_2\text{O} = (\text{NH}_4)_2\text{CO}_3$.

Chromogenic Microbes.—The term "chromogenic" is applied to those which develop colouring matter. This is sometimes soluble, sometimes insoluble, in water. The microbes are always aerobic. The most remarkable form of chromogenic micrococcus is the *M. prodigiosus*, or red snow. The most remarkable of chromogenic bacteria are the bacterium rubescens of Ray Lankester (*Mic. Journal*, 1873), which appears in vessels containing decomposing astaci, and which is noticeable for its pleomorphism, and the bacterium cyanogenum, which is the cause of blue milk.

Pathogenic Microbes.—The pathogenic organisms are those which are capable of generating disease; and the evidence on which their disease-producing powers rest is, it must be admitted, sufficiently satisfactory, for no microbe is regarded as the cause of a disease unless it is, in the first place, found to be constantly present in that disease, either in the blood or in the tissues; secondly, unless when carefully isolated and cultivated, it can, when introduced into the body of a healthy animal, give rise to the original disease, and be again found in quantity in the body.

That the air contains a large number of particles floating in it has been shown by many observers, amongst whom Cunningham in India, Salisbury in America, Sanderson in England, Robin in France, and especially Miquel, of the Montsouris Observatory, may be mentioned. The apparatus of Miquel consisted of a S-shaped tube with a vane, so that the open mouth was always directed to the windward quarter. In the interior was an inverted funnel, the small extremity of which almost impinged on a horizontal plate of glass, the surface of which was rendered glutinous or adhesive by covering it with a solution of glucose in glycerine, and which was replaced from time to time. Examination of this plate showed some inorganic substances, such as fine crystals and iron; and many organic particles, such as vegetable cells and fibres, pollen-grains, grains of starch, the spores of penicillium, aspergillus, coremium, and some botrytidæ, septonema, the septate ends of leptotrichum, trichosternum septosporium, helicotrichum, vibrios, and many other spores; and, lastly, various animal substances, such as the scales of butterflies and moths, particles of wool and feathers, and also microbes. He has given an excellent graphic representation of the number of microbes contained in the air blowing from different quarters over the Observatory of Montsouris, which is situated to the south of Paris. From this it appears that the air picks up in its passage across Paris in the course of half an hour three times the number of microbes it contains when blowing over the country. In the water, as might be expected, they are still more numerous, and nothing shows more clearly the effects of the drainage of a large city into a river than the fact that at Bercy on the Seine, above Paris, the number of microbes was about 5,000,000, whilst at Asnières, below Paris, it was nearly 13,000,000 per cubic litre, whilst a litre of rain-water contained 248,000 (Miquel). That these particles not only enter our bodies, but are arrested and retained in them, is shown by the conclusive yet simple experiment of Tyndall, who, by transmitting a beam of electric light through air before and after it has been respired, showed that, however thickly populated before, it is entirely free from organic and inorganic particles after it has once passed through our lungs. It may be incidentally mentioned that many microbes exist under ordinary circumstances on or in our bodies. Such are those which Bizzozero has shown fasten on our dead and desquamating epithelial scales, the leptothrix found between the fingers and toes, the bacillus of the smegma preputii, the numerous micro-organisms found between the teeth in all but those who are exceptionally cleanly in their habits, and which have been described by Miller and Lewis, and the various microbes of the intestines. In regard to the life history of the schizomycetes, it may be said that they are all microscopic, and some of them only just visible under the highest powers. They are composed of a special form, named by Nencki microprotein, which is destitute of sulphur and phosphorus, and is not precipitated by alcohol. Some move, others are motionless. Some form a kind of gelatinous capsule, which, fusing with those of adjacent microbes, produce a zoogloea. Many require a special soil. V. Jaksch has shown that the micrococcus uree can grow on ammonium succinate and lactate and malate, but not on

ammonium formiate, acetate, or butyrate. Some require oxygen—the aerobic microbes of Pasteur; others can grow without access of free oxygen, obtaining that element from the soil on or in which they grow. Most grow best at some definite temperature. The multiplication of the schizomycetes takes place by fission only, or by fission and by the formation of spores. The separation and isolation of these micro-organisms is a matter of much difficulty, but it can be effected by Pasteur's fluid method, or, still better, by Koch's method of plate culture and growth in sterilised peptone gelatine and agar-agar.

True Breeding.—A considerable divergence of opinion still exists as to whether the various forms of microbes are really specifically distinct from one another, and whether successive generations so far retain their characters that they may be held, supposing the conditions to be similar, to breed true. This is obviously of importance in a sanitary and hygienic point of view, for, as Mitten-zweig (p. 25) has well expressed it, if a form of microbe which has been ascertained to possess injurious qualities can be developed out of a harmless form, it is impossible that we should ever be able to establish sanitary measures that are of the least value, since we are always surrounded by millions of germs which may at any moment develop into a dangerous enemy. On the other hand, if these prove to be specific varieties, it is perfectly possible that by gaining an accurate knowledge of its life history, its mode of origin, its favourite haunts, its mode of attack, the conditions of temperature and soil which are most favourable to its growth, its fruiting, the germination of its spores, and the like, we may learn to know an enemy, and may adopt precautionary measures which shall have for their object the extermination of the species in question.

Micrococci.—The pathogenic micrococci which are of interest to the surgeon are (1) those of the pus of open wounds, (2) the micrococcus of erysipelas, (3) the micrococcus of gonorrhœa, (4) the micrococcus of acute infectious myelitis, and (5) the micrococcus of progressive necrosis. The bacilli are (1) those of syphilis, (2) those of tubercle and lepra, (3) those of tetanus, (4) those of anthrax, (5) those of ulcerative stomatitis, and (6) those of foot-and-mouth disease.

Micrococcus.—Several forms of micrococcus are associated with disease in man. First, the staphylococcus pyogenes aureus. This was first recognised by Ogston in 1881 (*BRITISH MEDICAL JOURNAL*, March 12th, 1881). It appears in the form of spheroidal cells 0.87 μ in diameter, which may either be isolated or twin, or arranged in groups of four, or in the form of a short chain of three or four elements, but sometimes also in irregular groups, from which its name is derived. The colonies fluidify gelatine, but not agar-agar. When they are in contact with air, they assume a bright yellow tint, but if covered with a layer of oil, they remain white. This is the most common microbe found in collections of pus in man, and much evidence has been accumulated to show that either it or its excreta are the active agents in the production of abscesses; for, in the first place, Rosenbach and Passet have demonstrated that abscesses do not, as has hitherto been generally believed, necessarily result from the subcutaneous injection of even highly irritating substances—such, for example, as the oil of turpentine—unless some microbe be present; whilst certain forms of microbes are almost constantly found in abscesses, and some kinds of suppuration appear to be especially induced by the staphylococcus aureus. Thus, it may be regarded as peculiarly apt to occasion boils, acute abscesses, and empyema. It is found also in acute osteo-myelitis, though whether it is the exclusive cause of this disease is not certainly known. Other affections in which it has been noticed are metastatic affections, pyæmia, and ulcerative endocarditis. Mr. Hartridge and myself found it in the pus of a hypopyon. The poisonous qualities this kind of pus-microbe possesses are well shown by an experiment made by Garré, and quoted by Flügge, in which a little of the cultivated micrococcus rubbed into the completely intact and healthy skin of the arm irritated the excretory ducts of the glands of the skin, and occasioned a widespread group of furuncles. Other forms of staphylococcus have been described by late observers under the names of staphylococcus pyogenes albus, citreus, and tenuis, which differ in the two former cases in the colour assumed by culture-colonies, and in the latter by the slightly larger size of the cocci, and their disposition to exhibit two dark poles and clear equator. The citreus and tenuis forms are stated each to occur in about 10 per cent. of the pus removed from abscesses. Micrococci of pyæmia and of septicæmia have been described as occurring in the rabbit. Those of pyæmia were obtained from animals into which macerated fluid had been injected; those of septicæmia from those in which fresh meat infusion had been injected. Pyæmic micrococci are round; septicæmic are oval: the former mere points, only $\frac{1}{1000}$ th of an inch in diameter; the latter large, $\frac{1}{2500}$ th. Pyæmic micrococci cause strong infiltration at the point of inoculation. Peritonitis,

metastatic abscesses in lungs and liver, and the capillaries contain heaps of micrococcus-masses with blood-corpuscles enclosed, and there are many thrombi. Septicæmic micrococci cause no coagulation of the blood, never surround the blood-corpuscles, but push them to one side. There is no peritonitis; the blood-vessels are often filled with them.

Although the purulent discharges of gonorrhœa and of the purulent ophthalmia of new-born children were examined by many competent observers with a view of discovering the active agents producing these diseases, it was not till the technical methods of Koch had been introduced that any success attended the efforts made for the discovery of these agents. In 1879, however, Neisser first demonstrated the existence of a microbe, which has been recognised by nearly all microscopists, and is evidently intimately connected with the whole group of purulent and contagious diseases of mucous membranes. In the following year Bokai and Finkelstein obtained pure cultures of this micrococcus in the course of two or three weeks, and on introducing a small portion of such cultures into the male urethra an acute attack of gonorrhœa rapidly followed, though when a little eucalyptus oil had been added to the culture, which killed the micrococci, no effects were observed. A similar experiment was performed by Bockhart on a general paralytic. Haab found that the cocci of purulent ophthalmia were absolutely identical with those of gonorrhœa. According to Cornil and Babes, the microbes of gonorrhœa, when fresh, are small spheroidal bodies about four micro-millimètres in diameter, which appear to possess some power of motion. They are often arranged in pairs, or even in tetrads, the opposed surfaces being then somewhat flattened. Cornil and Babes believe they have recognised two forms, one a little larger than the other: the latter are disposed in heaps outside the cells; the former are within the cells. They colour easily with strongly staining agents, as methyl-violet and fuchsin, but do not stain when treated on Gram's plan. They are found in the epithelial cells, both attached and free, and in the pus cells. The gonorrhœal pus of the male usually contains nothing but micrococci; but that of the female, obtained or collected from the vulva, at the orifice of the urethra, or in the vagina, contains long filaments like those of *leptothrix buccalis*, and masses of large spores which fill the pavement cells of the membrane. The best, the fullest, and the most recent account of this form of micrococcus has been given by Bumm, whose description I shall follow. Bumm's experiments were made exclusively upon the conjunctiva, which, as he points out, presents special advantages for experiments of this kind; for, in the first place, it is very easily infected; the infection attacks the whole surface simultaneously, and does not slowly spread from point to point; the moment of the commencement of the inflammatory reaction can be precisely noticed, and a portion can without difficulty or harm be excised for examination. There can be no doubt that a very small quantity of the gonorrhœal pus, containing micrococci, is capable of spreading the disease, and the natural and healthy moist surfaces of the conjunctiva and of the urethra seem to be well adapted for their growth and multiplication, so that they appear in great numbers in the course of twenty-four hours. Whilst other forms of micrococci, if they enter the eye, are unable to effect a lodgment, but are washed away by the tears, the gonococcus cleaves, as Bumm remarks, with an eminently invasive force, to the superficial epithelial cells, and the soft protoplasmic substances they contain; they then grow down, for the most part, between the epithelial cells, till they reach the papillary surface of the mucous membrane, and at the end of the second day of infection, the whole epithelial investment is completely beset with diplococci. The membrane now begins to present signs of reaction; swarms of white corpuscles escape from the blood-vessels, and make their way between the tissue elements till they arrive at the surface of the epithelial investment. The cells of this layer, already disturbed in their arrangement by the growth of the fungus, become further separated by the intrusion of the white corpuscles and pus-cells, and may even be raised in flakes, and detached by the movements of the lids, leading to capillary hæmorrhages between the epithelium and connective tissue. In the event of a croupous exudation forming, the gonococci form rows and heaps between the fibrous network and the lymphoid cells. In the case of the eye, the disease stops suddenly at the limbus corneæ and at the margin of the lids, and when the epithelial investment is broken down, the microbes seem to have little power of penetrating the papillary tissue. They do, however, extend along the fibres of the fibrous tissue, and where these separate from each other form little colonies not exceeding the size of the area of a divided capillary. Coincidentally the phenomena of inflammation increase in intensity, the round cell infiltration extends to a depth of 2 mm. beneath the surface of the mucous membrane, and the cells become

tightly packed, and at this time the suppuration stage of the disease is fully developed. In the course of about four days, when the conditions are favourable, a renovation of the epithelial coat takes place, commencing from the scattered remains of the old epithelium; a single layer is first formed, and by proliferation of the cells of this, a second and a third are formed beneath the first, the cells being flattened, with fusiform processes. The development of the microbes now seems to terminate, though it may recommence, and solid rods of cells dip into the subjacent tissue, reminding the observer of the growing zone of cancrroid. The gonococci quickly die when introduced into the tissue of the cutis, which explains the negative results formerly obtained by the syphilographers, and Bumm considers on this ground that the statements of those who have found gonococcus in the knee-joint and lymphatic glands require corroboration. No doubt they had a micrococcus before them, but no evidence has been afforded that it was gonococcus. He has himself found in the pus of acute bubo diplococci, which, however, both by their staining with Gram's methods and their mode of growth when cultivated, proved to be *streptococcus aureus*. In this case the staphylococcus which is frequent in gonorrhœal pus had entered through erosions of the prepuce or of the urethra, and had occasioned the suppuration of the gland.

I need hardly say how valuable a knowledge of these organisms has proved in the prevention of a terrible disease—the purulent ophthalmia of new-born infants. Formerly of common occurrence in all lying-in institutions, it is now, or perhaps I ought to say it might be now, by the use of well-known precautionary measures, entirely abolished. Sexual connexion should not take place during the last week or two preceding delivery. The hands and (if such are required) the instruments of the accoucheur should be absolutely clean. If there is the least doubt as to the existence of any discharge in father or mother, the vagina may be washed out with a dilute solution of corrosive sublimate (1 in 10,000); and if any discharge show itself in the infant, it should be promptly met and arrested by the instillation of a drop or two of a solution of silver nitrate containing from 1 to 3 per cent. of the salt; and all head-coverings and napkins, shawls, and the like, to which discharge is likely to adhere and then dry up, should be frequently washed. By proceedings like these Credé, and the speakers at a recent meeting of the German Gynecological Society were able to point to the satisfactory result that, from an average of 150 cases per 1,000, the number of purulent ophthalmic cases in the German Lying-in Institution had fallen to 2, and even these were due to the fact that the appropriate measures were not properly carried out.

The streptococcus erysipelas was first noticed by Lukomsky (Virchow's *Archiv.*, vol. ix.), who found it at the margin of an erysipelatosus area where the disease was making active progress. The lymphatics of the skin presented the zoogloea of micrococci. The microbes in the centre of the area were dead. Orth and Fehleisen (*Ätiologie der Erysipelas*, 1883) have experimented largely with the cultivated forms. It appears to present subordinate forms in different instances. Inoculation of the erysipelatosus microbe into the ear of rabbits in most instances caused redness and increased heat of the ear, though less violent than when streptococcus pyogenes was introduced. The inflammation began in from thirty-six to forty-eight hours after inoculation, in the form of a well-defined area of redness, which extended in the course of the veins to the root of the ear. The animals soon recovered completely. The difference between this microbe and that of ordinary pus, which it closely resembles in appearance, rest, on experimental and clinical evidence. Streptococcus pyogenes occurs, according to Flüggé, in about one half of all kinds of pus, while that of erysipelas occurs only in this affection, and is capable of being transmitted from one person to another. Fehleisen has continued the culture through seventeen or more generations on sterilised gelatine, and has still found that when inoculated into patients with a view of curing lupus, cancer, and sarcoma, a typical attack of erysipelas was induced. The subject of acute infectious osteomyelitis was first worked at by Rosenbach, who thought the infection might be analogous to one of the ordinary ferments, and from experiment he arrived at the conclusion that it was the lactic acid ferment; but Kraske has quite recently demonstrated that several microbes are present in this disease, and that in all probability the active agent is the well-known form of micrococcus named *M. pyogenes aureus*, the co-operating agents being the *M. pyogenes albus*, the streptococcus pyogenes, and some forms of bacillus. The paths by which the poison may enter the system are various, and Kraske reports one case where a fatal case started from a furuncle on the lip. Similar results have been obtained by Becker.

Bacilli.—From the micrococci exemplified in these forms of suppuration let us turn to the other grand division of microbes, the

bacilli. A typical example of the bacillus is presented by charbon, which has been so fully worked out by Koch and Klein; no spores are formed in the animal body; it increases only by fission in that situation. This bacillus is one of the most interesting on three grounds; first, that it was the first instance in which a microbe could be shown to induce disease; secondly, because it can attack man as well as animals, though certain breeds show themselves to be exempt from its attacks; and, lastly, because by inoculation its virulent effects can be greatly modified. The charbon bacillus belongs to the aerobia, since its growth is almost arrested when the access of oxygen is cut off. The colonies, when nourished on gelatine, form small punctiform masses with wavy contour, which quickly spread over the surface of the gelatine, effecting partial fluidification. A mere trace inserted into the veins of mice, rabbits, guinea-pigs, hedgehogs, sparrows, sheep, or horses, causes sickness, which, in the mouse, may kill in twenty hours, and, in rabbits in forty-two hours, the bacilli being found, after death, in the spleen and in the capillaries of the lungs, liver, kidneys, and intestines. Pasteur and Toussaint made the extremely important discovery that the exposure to moderately high temperature materially diminished the virulence of charbon bacillus, and that its action was also softened by certain poisonous substances, though their morphological features remained unchanged.

The presence of peculiar forms of cells in syphilis had been announced by Hallier, Losterfer, and others some years ago, before precise methods of investigation had been devised; but it was only in the course of last year that Lustgarten (*Wien. Med. Jahrb.* 1885), obtained, by special modes of staining, evidence of the presence of a microbe peculiar to syphilis. His plan was to make sections, and place them in aniline water and a concentrated alcoholic solution of gentian; to remove the dye in a solution of potassium permanganate; the brown flocculi of reduced manganese dioxide were then removed with sulphuric acid, and the sections then appeared completely colourless, with the exception of the bacilli of syphilis. Lepa and tubercle bacilli were stained in the same way. The bacilli found in syphilitic neoplastic formations resemble those of tubercle, and are usually curved, sometimes in opposite directions, and are, on the average, 4.5μ long, extremes being met with varying from 3 to 7μ . They often present a feebly marked enlargement at one extremity. The contours are not always parallel, but have kinks and indentations in their course. With high powers the bacilli appear of a deep blue tint, and have bright oval spots arranged at equal distances from one another in their interior, which he thinks are to be regarded as spores. The bacilli are contained in large oval or polygonal cells, where they occur in groups of from two to eight, intercrossing with one another. On the whole the bacilli are rare, so that several sections may be made before a single bacillus-containing cell can be found. In examinations of sixteen cases, Lustgarten found these cells to be invariably present, and in particular he found them in a periosteal gumma in a case of congenital syphilis. On the other hand, he was unable to find them in two excised soft chancres, and in numerous pathological as well as healthy tissues which were examined after similar treatment; and the same difficulty has been experienced by other observers, and especially by Alvarez, who believes he has found the syphilitic bacilli of Lustgarten, or organisms indistinguishable from them, in the smegma of the prepuce or of the vulva.

Strümpell (*Neurolog. Centralb.* No. 19, 1886, p. 433) has quite recently called attention to the etiological relations that exist between tabes and progressive paralysis and syphilis. He found that in 61 per cent. of the cases of tabes that had fallen under his own observation syphilis had previously certainly existed, and that in no less than 90 per cent. it had probably been present. He endeavours to show by citing the analogous nerve degenerations that occur in diphtheria that we have not here to deal with the deposit of the primary disease-producing microbe in the nervous system and its multiplication there, but rather that the secondary disease proceeds from some chemical poison produced no doubt by the original microbes. Similar nerve conditions occur after typhus and after dysentery. The most severe forms of nervous affection may follow the simplest and slightest attacks of these diseases. The attack of tabes so long after that of the original syphilis is not surprising when we reflect how chronic a disease syphilis is. It must be acknowledged, however, that the view that the secondary affections of syphilis are due to the secretion of syphilitic bacilli—that is to say, to ptomaines produced by them—is far less probable than that the bacilli wander from the original seat of inoculation and induce local disease. Take, for example, syphilitic iritis. Surely the blood poisoning which would excite a sharp attack of iritis would produce serious disturbance of many other organs; but we can easily explain the occurrence of the iritis if we admit that the bacilli are carried by the current of the blood, till they are arrested in

some spot which, like the highly vascular iris, is well fitted for their multiplication; and it is not, then, surprising that there may be no other signs of constitutional disturbance than such as are occasioned by the local conditions of pain.

Another subject of the highest possible interest to the surgeon—the etiology of tetanus—has recently received some elucidation from the labours of Roser and Heiberg, of Rosenbach of Göttingen, and of others. The causes of this affection have hitherto been in the last degree obscure, and I need hardly do more than refer to the reflex irritation theory. Roser and Heiberg first suggested that, owing to the formation of some miasm, a poison was generated which, being absorbed, caused the disease. Though supported by many observers, as Arloing and Triper, Billroth and others, endeavoured to transmit tetanus by inoculation, and failed. In fact, these negative results appear to be attributable to the circumstance that dogs were chiefly used for experiment, animals that appear to be singularly indisposed to suffer from tetanus. The first positive results were obtained by Carle and Rattone, who obtained from a pustule of acne, matter which being injected into twelve rabbits, caused eleven to be infected with tetanus; and further, the disease was transmitted from one of these animals to another. More recent observations have been made by Rosenbach (*Centralb. f. Clin.*, No. 24, 1886) who took the material for his experiments from the body of a workman, aged 23, who, in February of the present year, had frost-bitten feet, and who died the day after his admission into hospital, from tetanus. It was taken an hour after death from just below the line of demarcation. Two guinea-pigs, into whose thighs small fragments were introduced in the evening, exhibited well-marked tetanus the following morning, and died in the course of the day. The inoculation of other animals from these only succeeded when the material used for inoculation was taken from the immediate vicinity of the point inoculated. But when this was done, four guinea-pigs and eleven mice were rendered tetanic. The tetanus thus produced was in all respects identical with Nicolaier's earth-tetanus. It differs in the order of the appearance of the symptoms according to the position of the place where the inoculation is made. For example, if in a mouse the inoculation is made in the groin, the tail is found, after incubation of from nine to twelve hours, to be erect and directed stiffly to the side inoculated. The corresponding leg is stiff in all its movements, and is soon stiffly extended, the sole turned upwards, the toes clenched. The same phenomena are then seen in the opposite posterior extremity. The stiffness extends to the lower muscles of the back. The animal can only move by means of its fore feet. After the lapse of eighteen hours the anterior extremities become stiff, and immediately after trismus and opisthotonos, and, with every touch, even mere contact of the glass jar, tetanic spasms set in. The animal then lies in a state of exhaustion, with intense dyspnoea, and soon only slight shallow respiratory movements and feeble convulsions afford evidence that life still persists. Death usually takes place in twenty-four hours. If a mouse were inoculated at some other point—as, for example, over the humerus—the extremity soon became motionless, and quickly became prone and stiff; a few hours later the ear fell back, the prominent eyeball of the field mouse became retracted, the lids half closed, the jaws tightly closed; eighteen hours after the inoculation the whole body was bent towards the inoculated side, the left fore foot stiff, the hind foot movable; on contact tetanic cramps were excited, and again in twenty-four hours the animal was dead. The process was the same in guinea-pigs and in rabbits, though in the latter animals the general tetanic convulsions were less marked. The period of incubation is at least twenty-four, and in the majority of cases, thirty-six hours. Professor Flüge and his coadjutors informed Rosenbach that they had been able to obtain pure cultures of earth-tetanus-bacillus, but that they experienced great difficulty in transferring such pure cultures from one medium to another. Experiments made with a view of explaining this peculiarity suggested that the presence of some other fungus was requisite; in other words, that, as occurs in some of the higher animals, commensalism existed, perhaps due to the fact that the companion fungus promoted its growth by absorption of oxygen; and this observation, if supported by others, is interesting in connection with the fact that tetanus is peculiarly liable to follow wounds in injuries in which foreign bodies or necrosis and gangrene are present. The question whether the tetanus bacillus spreads itself throughout the body, and by what channels this occurred, has been the subject of many researches by Nicolaier, who found the bacilli in question once in the sciatic and twice in the spinal cord. Inoculation with fragments of organs succeeded fourteen times in fifty-two experiments. As the bacillus does not appear to be very abundant, it is difficult to understand how the simple growth of a fungus could produce such violent effects upon the nervous system; and it seems more probable that, as

the old supporters of the zymotic nature of tetanus thought, some kind of poison resembling strychnine was generated by the bacilli. We may suppose, then, that the bacilli streaming forth from the point of inoculation, as from a centre, distribute themselves through the body, and, further, that each bacillus lying in tissues represents a small but constantly acting source of poison, which first affects its own immediate vicinity, but, as a consequence of absorption and in co-operation with others, affects ultimately the whole body, and we may thus explain the local tone and tension, its gradual extension, and, finally, the affection of the whole system.

It is interesting to consider how these organisms exert their baneful influence on the living bodies of the higher animals. How, for example, do the bacilli of splenic fever act upon cattle? There are clearly four ways in which we may explain the action of microbes upon the infected animal. In the first place, they may act like an invading army on a peaceful population; they may simply consume their stores of pabulum. Possessing greater strength and vitality than the normal tissues, which are highly specialised and perhaps require more complex food—that is, food which has been more or less highly assimilated,—these young and vigorous warriors seize upon and appropriate the raw material, and practically starve out the more delicately framed cells. And this action cannot be overlooked, in whatever mode we may seek to explain their influence. Their enormous rate of reproduction has been already referred to, and we have only to look at the drawings of Klein and others of the thorough infiltration of many organs to understand what a powerful influence they must exert in this direction, and how the normal cells weakened by inanition may fall, like Gulliver before the Lilliputians, victims to the attacks of their minute but numerous and persevering enemies; and, if any further proof were needed, it would be found in the serious effects that are produced upon the economy by any constant drain, whether it be from an imperfectly healed abscess, from leucorrhœa, or even from purulent ophthalmia. Secondly, they may act by interfering with the due performance of the functions of the various depurating organs. Klein, in his numerous and excellent drawings, has frequently represented the kidney, and we see the capillaries of the glomeruli blocked up with myriads of microbes. It is clear that the urea and other final products of the regressive metamorphosis of the tissues must be imperfectly eliminated, and if retained in the body must contribute their share in the development of disease.

But another view may be held. It may be said, so far as we know, all living beings produce excreta, the simplest of which, carbonic acid and water, contain the carbon, hydrogen and oxygen of the food; whilst the nitrogen is eliminated in the form of urea or uric acid or guanin, or some other soluble and generally poisonous compound. Microbes can constitute no exception to this rule; but, whereas in most instances the products of excretion are thrown forth into the vast receptacles of the atmosphere or of the waters or of the soil of the earth, and by the play of other forces become harmless, they are here discharged into the body of the animal on which they are living, and so bring about its destruction more or less quickly, but as surely as if that animal's own excreta were retained in its body.

There is still another explanation which on many grounds has recommended itself, as accounting more satisfactorily for the phenomena observed, both to chemists and biologists. It is that the injurious effects produced by microbes are due, not to what they take or to what they excrete, but to what they leave, and this is closely associated with the imperious demand they make for oxygen. Being in many instances anaerobic—that is, living and multiplying without direct exposure to air—they must obtain the oxygen they require for the process of life from the tissues by which they are surrounded; but when oxygen is withdrawn from such complex chemical compounds as those of which our bodies are constructed, the elements enter into new combinations, and then, under the name of ptomaines (from *πτῶμα*, a dead body), are believed to be the really poisonous agents. Attempts have been made to isolate these compounds; and it has been shown that they are of the nature of alkaloids, and resemble, both in their constitution and in their effects, those deadly poisons that may be extracted from digitalis, conium, tobacco, delphinium, and other noxious plants. In reference to this, it may just be noted that Miquel (*Les Organismes Vivants*, 1883, p. 103) has cultivated a bacterium which has the singular power of converting a gramme of sulphur in the course of forty-eight hours into hydro-sulphuric acid on the addition of four litres of boiling water and some tartrate of ammonium. This bacterium often fixes itself in vulcanised india-rubber tubes, and in the course of a few hours can charge the water they contain with from 60 cc. to 70 cc. per litre of sulphuretted hydrogen.

The difficulty which must strike everyone in regard to the action of these microbes on the body is the comparative rarity of disease. How is it, if the air is swarming with these ferocious microbes, that we do not all succumb to their attacks? How can anyone escape? Pasteur meets the difficulty by stating that the healthy body is capable of resisting the attacks of these foreign agents, and that so long as the surface is intact no harm comes from their ingestion. A healthy man is probably capable of resisting the attacks of the majority of pathogenic organisms, at least for a time. The cells which cover the surface of our bodies and line our alimentary, respiratory and genito-urinary tracts possess their own vital energy, and when perfectly normal cannot be invaded by any microbe; they present an impenetrable front to such organisms along their whole line. When, however, by mechanical, chemical, or other injury the vitality of these cells is lowered, a door is opened for the admissions of such organisms, which, having once penetrated the tissues or the blood, find a fit soil for multiplication; and these may prove, by their mere numbers or by their effects, injurious or fatal to the whole body. Nothing can demonstrate this better than the experiment recently made by Orth and Wyssokowitsch (*Virchow's Archiv*, Bd. ciii., 1886), who found that staphylococcus could be injected into the blood of a rabbit without apparent injury; but, if before the injection, a slight mechanical injury was inflicted on the valves of the heart, typical endocarditis was at once produced.

In conclusion, I would desire to point out that this branch of inquiry is of quite a special character, and that it requires very considerable practice and entire devotion of time. Take my own case. I was most desirous to obtain cultures from various diseases of the eye attended with suppuration, to illustrate this lecture, but it is requisite, in the first instance, to have sterilised tubes and plates to grow the microbe. Though pretty well accustomed to delicate operations, very special precaution is required to introduce the matter gained without entrance of foreign bodies. Then an incubator is wanted; and, finally, there is the long and difficult examination with the microscope, with all its details of cutting, staining, mounting, and, not least, preserving in an accessible form. On these grounds, I hope that the Council of the College will see fit to institute, with part of Sir Erasmus Wilson's bequest, a laboratory devoted to this object, where one or two able demonstrators may continue the study of bacteriology, and prosecute, with all modern appliances, those researches, which are certain to prove of service in the diagnosis and treatment of disease.

PATHOLOGY OF ANEURYSM.

Read in the Section of Pathology at the Annual Meeting of the British Medical Association in Brighton.

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I UNDERSTAND it to be the wish of the managers of this meeting that the discussion which they have asked me to introduce shall turn rather on the practical aspect of the question than the theoretical—that is, shall bear on medical and surgical practice, rather than anatomical details. The time at our disposal does not allow of a complete treatise on the disease; and, therefore, all I shall here attempt will be a discussion of some of its main particulars, in connection with points of practice which are still unsettled. I shall speak of the influence of syphilis in causing aneurysm; of the relation between the aneurysmal tumour and the mouth of the sac; of the vital actions of the sac itself, and of some of the methods of spontaneous cure; using these pathological questions as illustrating the treatment of the disease (1) by medical means, (2) by the old operation, (3) by electrolysis, (4) by the introduction of foreign bodies, (5) by manipulation, (6) by Esmarch's bandage and by flexion, (7) by rapid pressure, and (8) by the distal ligature.

It is evident that I can only touch on all these matters very lightly, and that my office to-day is rather to start doubts than to solve them.

Stated generally, the cause of aneurysm may be said to be the weakening, in a given spot, of the resisting power of the wall of the artery to the blood-pressure. The artery is weakened by a wound or laceration of the external coat, or of the whole wall of the vessel, or (which I believe is common) by laceration of the internal coats, so that the blood insinuates itself beneath the external coat, and distends it; or an atheromatous patch deprives the artery of its elasticity in that