Melbourne, and Cape catalogues by the diurnal nutation and the annual displacement of the pole of inertia, the probability of the existence of diurnal nutation from observations, Chandler's formulæ for computing the variations of latitude, planetary aberration, and the new method of reckoning time (one to twenty-four hours) on the railways. All that one can desire to know about the weather in Belgium during the past year will be found in the excellent summary given by the meteorological director of the observatory, M. A. Lancaster. Several interesting plates are given in his summary. Towards the end of the book various miscellaneous tables and yearly summaries will be found of general interest.

THE JAMES FORREST LECTURE—BACTERIOLOGY.

DR. G. SIMS WOODHEAD, Director of the Laboratories of the Conjoint Board of the Royal Colleges of Physicians and Surgeons, delivered the James Forrest Lecture before the Institution of Civil Engineers on March 18.

After a short introduction, the lecturer sketched briefly the history of bacteriology, and gave an account of Leeuwenhoek's observations, some of which were either directly or through his friends communicated to the Royal Society of London. The organisms described by Leeuwenhoek, in 1683, "were so small that they did not appear larger than represented at E (giving a copy of the figure). The motion of these little creatures, one among another, may be imagined like that of a great number of gnats or flies sporting in the air. From the appearance of these, to me, I judged that I saw some thousands of them in a portion of liquid no larger than a grain of sand, and this liquid consisted of eight parts water, and one part only of the before-mentioned substance taken from the teeth." Leeuwenhoek's microscopes magnified from 40 to 160 times. At that time he had not made up his mind as to the exact nature of these organisms; he spoke of them as living animalculæ, but in some of them he was unable to detect the slightest movement or any sign of life, nor did he theorise as to the meaning of the presence of these organisms in the situation in which he found them, though later, in 1713, he appeared to be under the impression that the organisms seen in the teeth were conveyed into the mouth by drinking-water that had been stored in barrels.

The various forms of bacteria were then briefly described, their size, structure, and mode of growth. Alterations in form were noted, and the marked differences, not only in minute structure, but in mode of growth, and in the nature of their products were indicated. The modifications in the sheath or covering of these organisms were demonstrated, and the frog, spawn, or living glue masses were explained. Fine flagella were shown in organisms that differed very widely as to their nature and functions, and it was pointed out that, from what we know, however, of other flagella and cilia, and from recent observations on the arrangement of the pores in the membrane, and the relation of the flagella to these pores, it is to be anticipated that they are usually, at any rate, processes directly continuous with the central protoplasm of the organism. At one time it was supposed that these flagella were formed only in organisms that have a special affinity for oxygen; but within the last couple of years it has been pointed out that the tetanus bacillus, the organism which grows best where free oxygen is excluded, often presents beautiful flagellated forms, although—and this is an important fact—the organism, as pointed out by Kanthack, remains non-motile when examined under the microscope in the presence of oxygen. How it behaves when oxygen is excluded, has not yet been determined. Even those which have an affinity for oxygen appear to lose their flagella as soon as they leave the surface, and no longer require to move about in order to obtain this substance.

Spore formation was fully described, and the great resistance that these "seed" spores present to heat and chemicals was noted. As an example of the importance of this spore formation, what takes place in the case of the splenic fever bacillus that is found in cattle was mentioned. When an ox dies of anthrax there are found in its blood an enormous number of short thick rods, the anthrax bacilli. If a drop of the blood be taken from a blood-vessel immediately after the death of the animal, the rods will be found, on microscopic examination, to contain no spores—that is, there are no bright points in the substance of the rod, and the animal, if buried at once before any blood or discharges from the body can get on to the land where the animal has died, will not be a source of infection; the putrefactive organisms that develop being sufficient to kill off the anthrax bacilli that are in the blood. If, however, the animal be cut into, and blood be allowed to escape so that the organisms come into contact with the air, and the condition of the blood is altered in such a way that the nutritive supply of these organisms is gradually cut off, spores immediately begin to develop in the bacilli, and, as soon as this takes place, it is an exceedingly difficult matter to get rid of the disease; mere burial is certainly not sufficient, as the spores are not affected by the putrefactive organisms and products—they retain their vitality, and only wait for more favourable conditions under which to become again developed into the active and virulent anthrax organism. The knowledge of this fact, of course, has a most important bearing on the treatment of carcases of animals that have succumbed to anthrax. Other forms of spores of a less resistent character have been described; but it is scarcely necessary to do more than mention them, as they are not yet accurately understood.

As to the effects of temperature upon micro-organisms, it has been found that most of the saprophytes (those that grow upon dead matter) flourish most luxuriantly at the ordinary temperature of water, whilst the parasite or disease-producing bacteria grow and multiply most rapidly at the temperature of their animal or plant hosts. Most of these are killed at a temperature of 60° C. (140° F.). Certain bacteria, however, especially those found in soil and river mud, develop readily at 60° or 70° C., and flourish most luxuriantly at 50° C. C. Globig, and also, quite recently, A. Macfadyen, have shown that there are numerous organisms which can exist at temperatures even higher than this, in spite of the fact that they contain no spores. Of the spore-bearing organisms Dr. Woodhead showed the tetanus and anthrax bacilli, both of which are pathogenic or disease-producing, and the bacillus subtilis or hay bacillus, which is found especially in hay infusions, and appears to be associated with the reduction of organic matter in the process of putrefaction.

The production of enzymes, of acids, and of gases was described to indicate what different functions these organisms may have; and the different ways in which the aerobes and anaerobes are able to take the elements they require for their nutrition, and for the carrying on of their special functions, were explained, and the importance of these processes in the transformation and breaking down of dead organic matter insisted upon. In nature the process of disintegration of such matter is divided essentially into three parts. It is necessary (1) to get all solid matter into solution; (2) to supply as large a quantity of oxygen in as short a time as possible to this organic matter; (3) to attack the organic matter in solution by means of micro-organisms, and to so break it up that the various elements of which this complex material is composed may be thrown into an unstable or nascent condition so that the oxygen present may have an opportunity of entering into combination, and of forming what are called oxidised substances. It is evident from what we know of putrefactive processes that these changes may take place in two perfectly different ways. In the one case we have the oxidation taking place directly, all the nascent substances being satisfied by the oxygen of the air, and the splitting up of the organic matter being carried on by aerobic organisms. In such a process of oxidation which takes place in porous soil well supplied with air and moisture, and also in water which is from time to time well saturated with oxygen, it will be found that little or no putrefactive odour is developed. The marsh gas, the sulphuretted hydrogen, and other similar substances as they are set free, rapidly combine with oxygen to form sulphuric acid, carbonic acid and water; the nitrogenous substances in a similar fashion combining to form nitrous and nitric acids. In the soil these acids combine with the various basic substances, lime, magnesia and the like, so that they are rapidly removed and the way is left clear for the formation of fresh batches of the same substances. In anaerobic putrefaction, on the other hand, the process does not go on in this unobtrusive fashion, the anaerobic organisms having, as it were, to wrest their oxygen from the organic molecules because there is no free oxygen present, set up a much greater disturbance, and the products of the decomposition, such as sulphuretted hydrogen, marsh gas and ammonia, are thrown off in an unoxidised condition, and in the free form (*i.e.* no longer in a nascent condition), they remain comparatively stable, and give rise to the odours so characteristic of rapid anaerobic putrefaction.

The action of light and air was discussed and illustrated, and the relation of nitrifying organisms to the enriching of the soil; the effect of certain organisms which have the power of taking nitrogen from the atmosphere, and of conveying it to plants, was also illustrated. The history of Spontaneous Generation was touched upon, especially in so far as the study of this will-o'-the-wisp had led to the advances in our knowledge of bacteriology.

In relation to disease, the part that bacteria play as ultimate causal factors was described as one of prime importance. If bacteriology had done nothing more for us than draw our attention to the concrete specific bacillus as a cause of cholera, or example, so as to allow us to concentrate our attention on special preventive measures, instead of leaving us to wander in the wilderness of "conditions of soil," of "atmospheric influences," of "epidemic waves," and the like, its value would have been amply demonstrated. Without undervaluing in the slightest degree the careful observations that have been made by eminent epidemiologists, whose work has a value which can only be enhanced by what can be added to it by the bacteriologist, it was pointed out that since Koch's investigations have been accepted as trustworthy, and as the basis on which preventive measures may be founded, we in this country, at any rate, through our admirably constituted Local Government Board, with its organised staff of medical officers and inspectors, have been able, without resorting to strict quarantine, to deal with the specific cases of cholera that have been brought to, or have appeared on, our shores in a fashion that even a few years ago could never have been anticipated. It was further insisted that whatever great predisposing causes may be at work, whatever subsoil, atmospheric, or other conditions may be necessary for the production of an epidemic disease in our midst, we have ample evidence that without the introduction of a special and specific causal agent from outside, we have never had an outbreak of this specific infective disease. Of course, in every outbreak there were men who came forward to show, on the one hand, that only Koch has right on his side, and, on the other, that all wisdom lies in Pettenkoffer's theory. But few seem to act as if, whatever they may believe, the observations of both should receive serious consideration. Seasonal variations, temperature, drainage, rise and fall of ground water, all play an important part in determining the conditions of growth of bacteria; whilst, on the other hand, bad ventilation and filth, famine and illness, all predispose patients to attack. But without the specific organisms that actually set up infective diseases, no infective diseases will occur. Celsus, the great physician, taught that predisposing causes alone were insufficient to set up disease; whilst, on the other hand, exciting causes by themselves were powerless to act. But when they came to act in combination, he maintained that they were both sure and far-reaching in the production of disease. The same applies to-day, whether we have to deal with diphtheria, typhoid, cholera, or tuberculosis. Pettenkoffer deals with predisposing causes and conditions, Koch with exciting factors—bacteria. When disease has not yet come amongst us, let us follow Pettenkoffer; but when it is in our midst, or in our immediate vicinity, Pasteur, Koch and Lister are immediately advanced to the position of more trustworthy guides and leaders.

Sixty years ago, the year of the accession of the Queen to the throne, the proof that the yeast plant was a living organism and the cause of the process of fermentation, was almost complete, whilst only a year later the germs of the silkworm disease were observed; but it was not until more than twenty years after that, that Pasteur was able to point out the full import of these discoveries. Pasteur's work on fermentation and on disease, his experiments on attenuation of organisms, on protective inoculation and on curative injection for hydrophobia, have already been referred to, and are so well known that it is unnecessary to do more than mention them. Koch was able, by his new methods of separating organisms and solid media, to go beyond Pasteur in isolating the anthrax bacillus, and in proving to absolute demonstration the relation of the anthrax bacillus to splenic fever. His ingenious methods of cultivating organisms, of staining them in tissues, and of separating the different species, created a new era in bacteriology.

In our own country we owe to Lord Lister the great advances that have been made in the treatment of wounds, by which thousands of lives are yearly preserved, advances which date entirely from his study of bacteria and bacteriology. Antiseptic surgery, like the antitoxic treatment of diphtheria, is based entirely upon the early researches on bacteriology, and its development has followed most closely the advances made in that subject. "As yet no one can say that we have reached even a resting-stage, and it behoves all those who desire to see advances made in the treatment and prevention of disease, whether in the department of protection and cure, with which medicine is specially concerned, or in the preventive department, with which you gentlemen as Civil Engineers have to deal, to continue to follow closely every new fact and every fresh theory arising out of new observations, in order that bacteria and the forces with which they are endowed may be made our well-disciplined servants, instead of being allowed to waste their energies as uncontrolled and uncontrollable masters."

THE PASTEUR MEMORIAL LECTURE OF THE CHEMICAL SOCIETY.

A SPECIAL meeting of the Chemical Society was held on Thursday evening, March 25, when Prof. Percy Frankland, F.R.S., delivered the Pasteur Memorial Lecture. Prof. Frankland commenced his discourse by pointing out that the consideration of Pasteur's work was a subject specially befitting the Chemical Society, inasmuch as he owed the training which enabled him to master so many and such various problems to that rigorous discipline to which in early years he was subjected in the pursuit of chemistry. Pasteur's interest in this science was exhibited at a very early age, and even when he was a lad at the provincial college of Arbois, his master cherished the ambition that he would one day occupy a chair at the famous École normale in Paris. This hope was well justified, for it was there that Pasteur, as assistant to M. Balard, commenced those epoch-making discoveries which have stimulated researches in, and practically founded, that fascinating and important branch of chemical science known as stereo-chemistry. Perhaps the most conclusive and eloquent testimony which we can have to the profound importance of Pasteur's researches in this direction is the tribute paid to them by one of his greatest followers, Emil Fischer, who acknowledged but a short time since that, despite the immense amount of work which has been subsequently carried out in this field, "there is hardly a new fact of fundamental importance which has been added to his discoveries."

It was at the École normale also that Pasteur, many years later, carried out his brilliant researches on the etiology of diseases. Pasteur was led to turn his attention to the study of fermentation phenomena by his removal to Lille, one of the leading industries of the district being the manufacture of alcohol from beetroot and grain; and in his desire to bring the work of his department into touch with local interests, he commenced that classical series of researches which he continued over a period of twenty years. In this field of inquiry he had his first passage of arms with the great Liebig; it is needless to say how Pasteur emerged victoriously from this contest, and succeeded in demolishing the chemical theory of fermentation processes which had been advanced and supported so eloquently by Liebig and other leading men of science of the day, and building up in its place that theory which the so-called "vitalists" had so long laboured ineffectually to establish. Pasteur's researches on fermentation also proved of enormous commercial benefit to France and the whole world, by indicating improved methods for the manufacture of vinegar, wine, and beer. Moreover, it was in the course of these inquiries that he established that process of preserving liquids by means of heat, now widely known as Pasteurisation. The story of the famous spontaneous generation controversy was told, and Prof. Frankland pointed out how, in pursuing the laborious investigations involved by his entering into this discussion, Pasteur was unconsciously preparing himself for the great work with which his name will always be associated—the inauguration of the modern system of preventive medicine. Already in his researches on diseases in silkworms, undertaken at the pressing request of his friend and former teacher Dumas, Pasteur was specially attracted by the question of contagion; and the valuable experience he gained in this work may be gathered from the fact that in later years, when any one presented himself and begged the privilege of being allowed to work in his laboratory, he used invariably to ask them if they had read his volume on silkworm diseases, and tell them that that was the best preparation they could have for working with him.