Bacteria and certain substances. This line of inquiry is of quite recent date, and promises to produce important and interesting results.

From all this we conclude, then, that in some cases the blood and tissues are, or include, a natural antidote; in others the antidote is not present naturally, and is only furnished by the Bacteria themselves, and still in others the tissues, though possessed of this antidote, may lose it owing to altered conditions.

Another point worth considering is the peculiar inimical action exerted by one microbe on the other: this practically means that the products of one microbe either prevent the growth of another microbe or neutralize its toxic action. It is perfectly well established that while the products of one microbe exert an inimical action, when present in sufficient amount, on the growth and life of the same microbe (the protective inoculation by chemical products of the Bacteria cited above), the accumulation of the products of the particular microbe interferes with, and eventually altogether stops the further growth of its microbe. Outside the body this is easily proved in artificial cultivations. Inside the body it is proved by those cases in which recovery takes place.

It has been shown that while some pathogenic microbes can well thrive side by side in the same culture, inside or outside the body, there are others where the growth of one is antagonistic to the action of the other: erysipelas and anthrax (v. Emmerich), swine erysipelas and swine fever, anthrax and *Bacillus pyocyaneus* (Charrin), anthrax and *Staphylococcus aureus*; this is due to the fact that the chemical products of one species inhibit or neutralize the other species. That this antagonism is really of a chemical nature is shown in the case of anthrax and *Bacillus pyocyaneus*; if the chemical products of this latter microbe be injected into the animal simultaneously or soon after inoculation with the anthrax bacilli, no anthrax disease ensues, the anthrax bacilli do not multiply and do not produce the disease. Apart from specific antiseptics, there exist, then, in the battle against the action of pathogenic microbes which have already entered the system of an animal, the following means: (1) the chemical antagonism offered by the healthy tissues themselves —in some cases this is nought, in others very great and powerful, alterable by various conditions; (2) the germicidal action of the blood and tissue juices of unsusceptible animals on the multiplication of pathogenic Bacteria within a susceptible animal; (3) the antagonism existing between the Bacteria and their own chemical products; (4) the antagonism of one species and its chemical products against another species. These principles have, then, to be borne in mind as indicating the ways in which the microbes can be prevented from producing eventually the disease in a body into which they have found access. Pasteur's hydrophobia inoculations, and many of the recently published results of curative inoculations against tetanus, against anthrax, and against diphtheria, are illustrations of these principles.

The principle on which Koch's antituberculous lymph acts is apparently of a different nature. Koch has found by experiment on guinea-pigs that if the chemical products or an extract of the substance of the tubercle bacilli be injected into a body affected with tuberculosis, the tubercular tissue becomes necrotic, while the tubercle bacilli themselves remain unaffected; at the same time a remarkable reactive inflammation sets in, by which the necrotic tissue becomes eliminated, either spontaneously, *e.g.* where the tubercular process is superficial, as in lupus of the skin, or it may be removed by surgical aid, as in tuberculosis of the bones and joints. All who have followed the numerous cases treated in this manner must agree that it is an immense advance on all previous methods of treatment of some forms of lupus and of bone tuberculosis.

After having shown you what an enormous amount of accurate knowledge about the nature and causation, about the prevention and treatment of infectious diseases has been gained by the experimental method and by this alone, it will hardly be credited that a number of persons, as well-meaning as they are ill-instructed, are still maintaining the contrary; it is they who have succeeded in inducing Parliament to pass a law restricting, if not in some cases altogether prohibiting, the use of that method. This law is interfering with research in this country to a large extent, and has even put a stigma on those who are engaged in elucidating truths that are for the benefit of mankind, and of the animals themselves: what can be of greater benefit in the battle against diseases than the knowledge of their causes, and the devising of means for their prevention and treatment?

Fortunately for progress in general, this country is the only one in which such restrictions disfigure the statute-book; other countries, more enlightened and able to recognize the value of researches of this kind, have wisely resisted the clamour for restrictions.

In connection with all this knowledge, of which I have only been able to give you an outline, I have heard it stated that "ignorance" (meaning the ignorance of former times) "is bliss" as compared with the present knowledge of the dangers surrounding us; but I have also heard it stated that the wise man, knowing and recognizing the nature of these dangers, has the possibility given him of avoiding and preventing them, and no truer words have been spoken than these, that "he who cures a disease may be the skilfullest, but he that prevents it is the safest, physician."

My best thanks are due to my friend Mr. Andrew Pringle for the admirable photographs prepared by him of the microscopic slides illustrating the different pathogenetic microbes exhibited, and to my friend and pupil Mr. Bousfield for the fine lantern slides of tube cultivations.

THE ROYAL METEOROLOGICAL SOCIETY'S EXHIBITION.

THE twelfth annual Exhibition of the Royal Meteorological Society was opened on Tuesday evening, March 3, in the rooms of the Institution of Civil Engineers, 24 and 25 Great George Street, Westminster. This year's Exhibition is devoted to rain-gauges and evaporation-gauges, and also such new instruments as have been constructed since the last Exhibition. It might at first be thought that an exhibition of rain-gauges would be a very small and insignificant affair, and would not be of any interest to the general public. Anyone, however, visiting the Exhibition will at once see that a very large collection of various forms of rain-gauges has been got together by the Society, and that the information obtained from the records of these simple instruments is of the highest importance. There are altogether fifty-six different forms of rain-gauges shown in the Exhibition, and it is interesting to compare the old with the new patterns.

Side-tube rain-gauges of various diameters are exhibited. In this instrument the water passes into the body of the gauge, and also into a glass tube in the front, and stands at the same level in each. As the combined area of these tubes is very much less than that of the receiving surface, the natural depth of the rain is proportionally increased, and thus the scale is lengthened in proportion—usually about eight or ten times—so that the quantity can be read off to hundredths of an inch. The objection to this form of instrument is that the glass tube is liable to be burst by frost, and the record lost.

Messrs. Negretti and Zambra exhibit a contracted float-gauge, the receiver of which contains a copper float, to the upper side of which a rod is attached. When rain falls, the rod is lifted, and, owing to the small area of the body of the gauge as compared with that of the rim, the float rises about eight times the natural depth of the rain.

Mr. Symons shows Fleming's rain-gauge, which is a very small float-gauge. This pattern was formerly much used in Scotland, but is now nearly abandoned, because when the quantity of rain collected exceeds 2 inches, rain which ought to pass over the gauge is caught by the measuring-rod, and runs down it into the gauge. It was also usually placed so nearly level with the ground that surface water occasionally entered.

Various modifications of Howard's rain-gauge are exhibited. This pattern was designed by Luke Howard, F.R.S., and engraved in the first edition of his "Climate of London," published in 1818. It simply consists of a funnel 5 inches in diameter, with a long tube at the bottom, which fits into the neck of a glass bottle. The area of the funnel is about eleven times that of the measuring-jar, so that minute measurements can easily be made. In 1850 a stone-ware bottle was substituted for that of glass, with the view of reducing the frequency of breakage. Mr. H. H. Treby modified this form of gauge somewhat by having rough divisions put upon the glass bottle, so that an approximate idea of the amount of fall might be obtained without the gauge being interfered with. Mr. Symons further modified this gauge by attempting to protect the glass bottle with an outer cylinder having two slits in it, so as to allow of inspection, as in Mr. Treby's gauge. This gauge, however, had two faults, viz. (1) the bottle did not hold enough; and (2) if it burst, the can, being pierced, could not save the water. This gauge was subsequently so modified as to remove the above-mentioned evils, the bottle being larger, and the can water-tight.

Glaisher's rain-gauge is 8 inches in diameter, and has a bevelled rim and curved pipe. The rim round the gauge, about two-thirds of the way up, was designed to make a water-tight joint, so as to prevent any of the rain inside escaping by evaporation. The same object was aimed at by the curved tube or inverted siphon, in which the last few drops of rain remained, and (until they dried up) formed a water-seal. This gauge has subsequently been modified by the substitution of a vertical rim (to cut the rain-drops) for the original bevelled one on which they would break, and by the substitution of a long straight pipe for the curved one, which was found to be frequently choked with leaves, &c.

In the autumn of 1864 the late Major Mathew undertook to provide a number of gauges for the district round Snowdon; for that district Mr. Symons provided gauges 5 inches in diameter, with cylinders rising 4 inches vertically from the edge of the cone of the funnel. These are called "Snowdon rims," and funnels so provided are gradually displacing all others, because they are so much better in time of snow. A gauge of this kind in copper is nearly indestructible and independent of frost, because two vessels (one of glass and one of copper) must burst before the water can be lost. Specimens of this form of gauge, Symons's Snowdon, are shown both in copper and in galvanized iron.

The Meteorological Office gauge, which is 8 inches in diameter, is generally regarded as the best gauge for ordinary observers to whom cost is not a primary object; it has all the good features of the Glaisher and of the Snowdon patterns, and being of copper is very durable.

Several mountain rain-gauges are exhibited. As these are for use in places where the rainfall is heavy, and where they can only be periodically examined, they are made to contain 40 or 50 inches of rain. The rod is detached from the float (to avoid error from its intercepting the rain), and is only dropped into the cup when an observation has to be made. The instrument has an outer cylinder to guard against frost, and to facilitate emptying.

The Manchester, Sheffield, and Lincolnshire Railway company, who for many years past have had regular rainfall observations made at about fifty of their stations, exhibit a specimen of the gauge they employ, which is 8½ inches in diameter, also a map showing the sites of their rain-gauge stations, and specimens of their forms and publication.

Mr. Symons shows a number of the original gauges which were employed about twenty-five years ago in the experiments carried out by Colonel Ward and others to determine (1) the effects of placing gauges at different heights above the ground, not (as had been done previously) on buildings, but on posts; (2) to ascertain whether there is any difference in the indications of gauges ranging in diameter from 1 to 24 inches, and including square ones of 25 and 100 inches area; and (3) to test the effect of various receiving surfaces, such as tin, copper, glass, porcelain, and ebonite.

Among the other old pattern gauges may be seen:—Stevenson's, which has the rim of the gauge brought to the level of the ground, and is surrounded by a brush to avoid in-splashing; FitzRoy's, in which the amount of rain is ascertained by a graduated dipping tube which has a hole at each end; the old copper gauge, with square funnel, used at the Kew Observatory from 1850 to 1890; and the coffee-pot rain-gauge—so called from its shape.

Mr. Symons shows both the first and second pattern of his storm gauges. These are not intended for general use, but to enable observers to watch the most minute details of heavy rain during thunderstorms. Carefully attended to, they yield information of the very highest importance, both for architects and for engineers, as to the rate at which rain falls. With one of these instruments in London on June 23, 1878, rain was ascertained to be falling for 30 seconds at the rate of 12 inches an hour.

The earliest registering rain-gauge is probably that known as Crosley's. The area of this gauge is 100 inches, and beneath the tube leading from the funnel there is a vibrating divided bucket; when one compartment has received a cubic inch of water, *i.e.* 0·01 inch of rain has fallen, the bucket tips, the index advances on the first dial, and the other bucket begins to fill, and so on indefinitely. Messrs. Yeates and Son's electrical self-registering rain-gauge is simply a Crosley gauge, in which electrical contact is made at each turn of the bucket, and the index hand moved one division. The advantage of this instrument is that the funnel may be placed in any exposed position out of doors, while the registering part can be fixed indoors.

The Kew Committee exhibit Stutter's registering rain-gauge, which has twenty-four collecting jars, one for each hour, and also Beckley's self-recording rain-gauge, which is the pattern in use at the Observatories in connection with the Meteorological Office; its funnel has a receiving area of 100 square inches, and is provided with a lip 1¼ inch deep, to retain the splashes. The rain flows down into a copper receiving vessel, which, floating in a cistern of mercury, sinks and draws down with it a pencil which marks on a cylinder moved by a clock. When the receiving vessel is full, a siphon comes into action and rapidly draws off the whole of the water, the vessel rising almost at a bound, the action being recorded by a vertical line on the cylinder. Mr. Casella shows the recording portion of his self-recording gauge, which is another mode of effecting the same object.

MM. Richard Frères, of Paris, exhibit two of their self-recording rain-gauges, which are very ingenious instruments and promise to yield good results. They are already at work at many stations on the Continent, and to our own knowledge at four in this country.

Several rain-gauges as used in foreign countries are included in the Exhibition. Prof. Mascart, of the Bureau Central Météorologique de France, has sent four specimens of gauges as used in France; and Dr. Hellmann, of the Kon. Preussisches Meteorologisches Institut, Berlin, has forwarded the first and second patterns of his rain and snow gauge (the latter of which is now used in the Prussian Meteorological Service), and also his gauge for measuring the density of snow. Wild's rain-gauge, as used in Russia, and Nipher's protected snow-gauge, as used in the United States, are also exhibited.

Among the miscellaneous gauges may be mentioned the marine rain-gauge, mounted on gimbals for use on board ship; Livingstone's rain-gauge, with funnel 3 inches in diameter, as made for the late Dr. Livingstone; tropical rain-gauge, with funnel 4½ inches in diameter, and receiver large enough to hold 40 inches of rain; Colladon's gauge for determining the temperature of hail; Sidebottom's snow-melting rain-gauge; and Mawley's snow-gauge.

Perhaps the largest rain-gauge that has ever been made is that employed by Sir J. B. Lawes and Dr. J. H. Gilbert on their experimental farm at Rothamsted; this has an area of one-thousandth of an acre. The funnel portion of this large gauge is constructed of wood lined with lead, the upper edge consisting of a vertical rim of plate glass, bevelled outwards. The rain is conducted by a a tube into a galvanized iron cylinder underneath, and when this is full it overflows into a second cylinder, and so on into a third and fourth, and finally into an iron tank. Each of the four cylinders holds rain corresponding to half an inch of depth, and the tank an amount equal to 2 inches. Each cylinder has a gauge-tube attached, graduated to 0·002 inch. Of course, this gauge itself could not be exhibited, but two of the collecting gauge cylinders are shown, as well as a coloured view of the gauge *in situ*, drawn by Lady Lawes. A coloured view of the Rothamsted drain or percolation gauges, drawn by Lady Lawes, is also shown. There are three drain-gauges, each one-thousandth of an acre area, which are used for the determination of the quantity and the composition of the water, percolating respectively through 20, 40, and 60 inches depth of soil (with the subsoil in its natural state of consolidation). Sir J. B. Lawes and Dr. Gilbert exhibit a table giving the results of rainfall and drainage at Rothamsted for the twenty harvest years ending August 31, 1890. The annual means are as follow:—

Rainfall.		Drainage through soil (uncropped).				Difference approximately = evaporation.		
		20 in.	40 in.	60 in.		20 in.	40 in.	60 in.
in.		in.	in.	in.		in.	in.	in.
30·29	...	14·38	15·16	13·61	...	15·91	15·13	16·68

The Exhibition also includes a number of evaporation gauges for determining the amount of evaporation from a free surface of water or from plants. The Meteorological Council exhibit von Lamont's atmometer, and Wild's, De la Rue's, and Piche's evaporimeters; Mr. Casella shows Babington's atmidometer, and an 8-inch pedestal evaporator. Dr. W. G. Black shows his floating rain-gauge and evaporating cup for use on ponds; and Mr. W. H. Dines exhibits the apparatus used by the late Mr. G. Dines for measuring evaporation. Mr. Symons shows the following from the series of evaporators constructed under the supervision of Mr. Rogers Field, and used in experiments at Strathfield Turgiss about twenty years ago, viz. Fletcher's, Watson's, Miller's wet-sand, tin, tin with overflow, Casella's can and bottle; also Field's hook gauge, used for determining the depth of water evaporated from the large tank, 6 feet square and 2 feet deep, which was used as the standard wherewith the foregoing and some other forms of instrument were compared. The Cambridge Scientific Instrument Company exhibit a self-recording evaporimeter, designed for use with growing plants in a botanical laboratory; and MM. Richard Frères show their self-recording evaporation gauge for use with either water or plants.

Several new instruments are also shown in the Exhibition, among which may be mentioned the following:—Latham's self-recording apparatus for wells, rivers, and reservoirs; Dines's and Munro's helicoid and Robinson's anemometers, and helicoid air-meter; and Richard Frère's statoscope (which is a very sensitive atmospheric barometer) and anemo-cinemograph. Mr. Clayden exhibits a small and large camera for meteorological photography, showing a simple method of attaching a mirror of black glass for photographing meteorological phenomena. The Kew Committee exhibit the frames designed by General Strachey and Mr. Whipple for measuring cloud pictures for determining the height and drift of clouds.

The Exhibition also includes a large number of photographs illustrating meteorological phenomena, &c., as well as a number of maps and diagrams showing the distribution of rainfall over various parts of the world.

The Exhibition will remain open till Thursday, the 19th instant.

William Marriott.

THE PTOLEMAIC GEOGRAPHY OF AFRICA.

At the meeting on Monday of the Royal Geographical Society, Dr. H. Schlichter read a paper on "Ptolemy's Geography of Eastern Equatorial Africa." Ptolemy, as a geographer, has received very different treatment at different times at the hands of his critics. At one time it was the fashion to sneer at the industrious Alexandrian geographer as entirely untrustworthy, as a mere imaginative arm-chair geographer, without critical discrimination. That Ptolemy was an arm-chair geographer no one denies, but in geography, at least, it should be remembered that the looker-on often sees most of the game. Basing his system on that of his predecessor, Marinas of Tyre, Ptolemy seems diligently to have collected the itineraries of all travellers that came within his reach, and his position at the great port of Alexandria was highly favourable for work of that kind. Of course his methods were faulty, his fundamental data erroneous, and the observations with which he had to deal often of the vaguest kind. Still, when all due allowance is made for these drawbacks, there is no denying that Ptolemy's map of North-Eastern Africa bears a wonderful resemblance to reality—just the resemblance that might be expected in the infancy of cartography, before the invention of instruments of precision, and ere travellers had learned to make good use of their eyes. Recent discoveries in Central Africa have attracted increased attention to the geography of Ptolemy, and make one wonder how he came so near the truth. It has been recently attempted by Dr. Meyer (who in this case is merely the mouthpiece of Mr. E. G. Ravenstein) to show that Ptolemy's knowledge of East Africa did not extend beyond Abyssinia; that his Nile is simply the Abyssinian River, and his lakes the lakes of that country, projected downwards, to suit later knowledge, into the heart of Africa. However that may be, Dr. Schlichter, in his paper, gives the result of an ingenious method adopted by him to test Ptolemy's accuracy, and to prove that he must have somehow obtained information about the lakes which we now know give origin to the Nile, and about the snow-clad mountains that cluster round them, and which are all that remain to us of the once famous Mountains of the Moon that extended like a barrier across the continent. After discussing Ptolemy's cartographical methods, and making allowances for his error as to the length of the degree (600 instead of 500 *stadia*), Dr. Schlichter's *modus operandi* is as follows:—

1. To look for the basis on the coast which Ptolemy used in order to fix the position of this part of Africa; and to eliminate his error of geographical latitude.

2. To reduce the positions of his points to modern graduation.

3. But in all other respects to leave the distances from the basis of the map intact with the exception of the itineraries round the Victoria Nyanza.