practical sanitarian (and many health officers from this country have had their opportunity and made good) who has handled malaria prevention has received results, and knows that thus only is success to be achieved.

It may seem somewhat parochial in a subject of such universal interest to bring forward evidence from limited operations in England; but they have been unique, in that it is the first opportunity that has existed of studying indigenous malaria in England with the knowledge of its entity.

I briefly sum up the evidence of recent occurrences in England in proof of the value of definite sanitary operations in the prevention of malaria. And as far as England is concerned, while it would be absurd and uncalled for to institute antimosquito measures throughout the entire area of anopheline distribution, there may be parts of the country where the coincident distribution of vehicle and carrier may be intense. In these it may be incumbent on authority to adopt the proven measures of malaria prevention.

Summary.

1. Mosquito prevalence was similar in 1917 and 1918.
2. Conditions for indigenous infection existed both in 1917 and 1918.
3. Carrier population was increased in 1918.
4. Where general measures were adopted, but when control was more accurate, the scattered occurrences in 1918 were 24, as against 26 in 1917.
5. Where sanitary measures were added to the scheme of prevention, as in Sheppey, the cases in 1918 number 45, as against 103 in 1917.
6. Where more accurate operations were attained in Sandwich the number of indigenous cases fell from 69 to 6.

THE ELECTRICAL CHANGES IN ACTIVE TISSUES.

ABSTRACT OF THE SILVANUS THOMPSON MEMORIAL LECTURE GIVEN BEFORE THE RÖNTGEN SOCIETY ON MAY 6TH, 1919.

BY

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The phenomena of electrical changes in active tissues have been a favourite subject of investigation by physiologists, no doubt greatly on account of the accurate methods of measurement available, even at a comparatively early date. Although electric fish were known to the ancient world, and the effects of their discharges were described by Aristotle and Pliny, it was not until about 1780 that Galvani discovered similar properties in ordinary muscle, naturally much less intense, and requiring delicate methods to detect them. Matteucci in 1838 appears to have been the first to use the galvanometer in their investigation, and the work of Du Bois-Reymond was only a little later. Before long, these properties were shown to exist in nerve, in glands, and in smooth muscle.

It is not my intention to discuss the details of all these cases, but rather to direct attention to certain facts which throw light on their manner of production and their significance. It may be pointed out that electrical changes are not in themselves of great importance, but rather as indicating the existence of phenomena otherwise difficult or impossible to investigate.

Since the introduction of the theory of electrolytic dissociation of conductors in watery solution, it has been realized that we must look for the explanation of the facts before us on the basis of the movement and redistribution of ions. The body may be regarded as a framework of non-conducting material, immersed in and soaked by solutions of electrolytes. Evidence derived from many and various sources shows that living cells are surrounded by delicate membranes, which allow water and certain solutes, such as urea and the lower alcohols, to pass through freely, but refuse passage to the majority of salts, to sugars, etc. It was pointed out by Ostwald in 1890 that if a membrane is impermeable to one of the ions into which a salt is dissociated, it is indifferent whether the oppositely charged ion can get through or not, because this latter can only leave the neighbourhood of its fellow for a very small distance on account of the great magnitude of the electrostatic attraction between them. It will therefore form a layer on the outer side of the membrane,

while the opposite ions form a layer on the inner side. This is the "electric double layer" described by Helmholtz, and is clearly the cause of a difference of potential between the two sides of the membrane.

Now Bernstein in 1902 showed that if we suppose the membrane of the muscle cell to be impermeable to certain anions but permeable to certain cations, the latter will form an outer layer with a positive charge, while the interior of the membrane will have a negative charge. He showed, moreover, how all the facts of "muscle electricity" are explicable on this view. What the particular ions are it is as yet impossible to state; but those of potassium phosphate seem to be the most probable.

What, then, are the facts to be explained?

1. Since the whole of the surface of the cell is supposed to be possessed of the membrane in question, it is easy to see that application of electrodes connected to a galvanometer should show that it is equipotential at all points. This is the case with uninjured muscle and also with nerve.

2. Suppose that the two electrodes are placed at different points and that we injure the membrane under one of the electrodes, so that it becomes freely permeable to both ions. The double layer ceases to exist at the injured point, the ions freely mix, and the electrode is in connexion with the interior of the cell—that is, the negative component of the double layer at the normal parts of the surface. We have what is called the "current of injury" or "demarcation current," in which the injured spot is negative to the uninjured parts. It is to be noted that the older theories regarded the changes at the injured spot as the source of the current, while the new view regards the uninjured surface as the source. Bernstein was able to decide the question in the latter sense by warming locally. The demarcation current was unaltered by warming the injured spot, increased by warming the normal place. The effect of temperature was also used to decide between a physical theory, such as that spoken of, and those theories which attributed the phenomena to chemical reactions at the injured spot. The magnitude of the current of injury was found to be proportional to the absolute temperature and not to have the high temperature coefficient of a chemical reaction.

3. The current of injury disappears more or less quickly, as it should do if the electrolytes within the cell diffused away at the permeable injured place.

4. There is evidence that increase of permeability is a general characteristic of the state of activity. Details of this evidence are beyond the limits of this account, but, accepting them, we may examine what would happen if we led off from the normal surface and from an injured spot and then stimulated the muscle to contract. The normal surface would approximate more or less completely, as regards its permeability, to the injured spot, the double layer would disappear and with it the source of the current of injury. This was called the "negative variation," that is, the decrease, of this current.

5. If both electrodes are on uninjured spots and a wave of excitation passes along the muscle, as it passes one electrode it makes this one negative to the other, and then, leaving the former, it reaches the second and makes this negative to the first. We have a current first in one direction, immediately followed by one in the opposite direction. This is the "diphase variation."

Their impermeability to ions makes cells bad conductors of electrical currents. Their resistance thus decreases in the state of activity or when the membranes are destroyed. This is the basis of Stewart's method of determining the proportion between the corpuscles and the plasma in the blood. It also accounts for the high resistance of nerves in the transverse direction.

The main fact that an active spot in muscle or nerve is negative to one at rest is therefore accounted for satisfactorily on the "membrane theory" of Bernstein.

As instances of the use of the fact may be mentioned Lewis's localization of the pace-maker in the mammalian heart and the extensive use of the electrocardiogram in practice. It is beyond the object of this lecture to discuss the meaning of the components of the latter, but a word of warning should be given against hasty interpretation of details in the curve. Slight changes in the duration of the excitatory state at one electrode may produce fundamental alterations in the electrocardiogram, while the heart beat, as far as its essential mechanical effects are

concerned, shows no change of practical importance or detectable by any other method.

The passage of impulses along a nerve cannot be detected directly in any other way than by the electrical effect. Einthoven has been able to show the passage of impulses in the vagus nerve when the lungs are distended or collapsed, and also in the depressor nerve when the blood pressure rises in the aorta. Piper has determined the rate of discharge of motor innervation. The method is capable of further extension to reflexes, and possibly the vexed question of the analysis of sounds by the cochlea may be decided.

The electrical changes in secreting glands are more complex than in nerve and muscle, and are not yet completely understood. The main component is undoubtedly connected with the flow of water, as shown by Bradford and myself, and to explain it we may consider briefly the nature of the secretory process in general. The cells possess the same kind of membrane as muscle has, but their impermeability appears to be to certain cations of the cell contents, not to anions, as judged by the sign of the electrical effects. This is, however, a matter of detail. During rest there is formation of complex substances to be used in the act of secretion. This is an automatic process, requiring the supply of energy by oxidation, and comes to an end by mass action of the products. When secretory activity occurs, two things happen. The stored products are split into smaller molecules, so that the osmotic pressure of the cell contents rises and water is attracted. But simultaneously that end of the cell in relation to the duct becomes permeable. Water flows out, carrying the secretory products. The electrical effect is accounted for in a way similar to that in the case of muscle. But there is also another component of the electrical change, smaller in magnitude and opposite in sign to that associated with the permeability effect. This is seen when the sympathetic supply to the submaxillary gland of the dog is stimulated. Its origin is unknown.

Sweat glands in the skin show the phenomenon of an electrical change. They are readily excited reflexly and, as Tarchanov and Wells and Forbes have shown, also by psychical events. It seems practically certain that the "nerve-leaks" of Baines are due to local activity of sweat glands. These may possibly be of use in the location of pathological processes in the central nervous system, but there are simpler means of detecting local sweating.

Waller has investigated the changes of resistance in the skin, which are associated with mental states, and proportional to the degree of the emotion. The phenomenon is called by him the "emotive response," and he is inclined to doubt its origin from sweat glands. But the evidence derived from atropine is not very satisfactory. The way in which the decreased resistance is produced in active cells has been described above. The reaction may be found useful in the process of "psycho-analysis" and has been used by Wells and Forbes in psychological investigations.

Photochemical reactions are associated with electrical changes, and the phenomena in the retina have been the object of much attention. They are complex in the vertebrate retina, probably on account of its mixed structure. In the cephalopod the effect of light is simple. When better understood, they will doubtless help to explain the retinal processes. The action of light on the green leaf has been shown by Waller to be accompanied by electrical effects. This again requires further work.

Finally, the process of inhibition in heart and smooth muscle may be referred to. Since increased activity means increased negativity, it is clear that decreased activity should be associated with decreased negativity. This was shown by Gaskell to occur in the tortoise auricle on stimulation of the vagus. In the ureter, it appears that a wave of inhibition precedes that of contraction, which propels the drops of urine downwards, a process similar to that described by Starling and myself in the case of the intestine. This would naturally result in a double electrical effect at each electrode and a complicated curve of the total effect, such as is described by Orbeli.

At the twenty-ninth annual meeting of the Association of Medical Colleges in Chicago a new constitution and by-laws were adopted, the principal modifications being in the high school and college requirements for admission to medical schools.

Lettsonian Lectures

ON

JAUNDICE: WITH SPECIAL REFERENCE TO TYPES OCCURRING DURING THE WAR.*

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LECTURE III.—PART I.

EPIDEMIC CATARRHAL JAUNDICE.*

This disease was very frequent in the Dardanelles campaign, in Egypt, and in Mesopotamia, and there is no doubt that it occurred frequently also in other war areas. The symptoms and course of the disease form a characteristic clinical picture, and undoubtedly constitute a special type of jaundice the exact pathological cause of which has not been ascertained.

I have had the opportunity of studying closely a very large number of cases, particularly in the Dardanelles and Mesopotamia, and the advantage of the co-operation of distinguished bacteriologists who have made the most painstaking and thorough examinations. From my own clinical observations, and from the results of these bacteriological examinations, I have not the slightest doubt that the epidemic catarrhal jaundice was a special entity, entirely distinct from *spirochaetosis ictero-haemorrhagica*.

The first published clinical description of the disease was by Lieutenant E. B. Gunson, R.A.M.C., and Lieutenant I. W. C. Gunn, R.A.M.C.,¹ who gave an interesting and accurate account of a series of cases in British troops at Alexandria in June, July, and August, 1915, nearly all from a single camp. In July, 1915, at a general hospital in Alexandria, the late Lieut.-Colonel Lister, R.A.M.C., who was in command of the Medical Division, kindly showed me a number of these cases, and I had the opportunity of examining them. I should like to take this opportunity of expressing the great admiration and regard of all who knew him for the skill, sympathy, and devotion shown by Lieut.-Colonel Lister in the splendid medical work which he carried on unremittently in Egypt even when stricken himself by an incurable malady which later called him from us.

On February 26th, 1916, an account of the epidemic jaundice in the Dardanelles was published by myself.²

In 1916 Major R. S. Archibald, R.A.M.C., and his fellow workers, Captains Hadfield, Logan, and Campbell, in their bacteriological reports³ from the Mudros laboratories, gave a full account of a great deal of careful work carried out on the cases of jaundice at the Dardanelles. On April 7th, 1917, a paper on the pathology and etiology of this disease was published⁴ by Lieut.-Colonel C. J. Martin, A.A.M.C. Hurst also refers⁵ to the disease in his book on the *Medical Diseases of the War* (1917).

In Mesopotamia I have studied closely a very large number of cases of this type of jaundice, and the most thorough and exhaustive bacteriological investigations have been carried out by Major Mackie, I.M.S., Major Gloster, I.M.S., Major Stevenson, I.M.S., and Captain Short, I.M.S.

SYMPTOMS.

The patient had usually some abdominal discomfort for a few days, associated with anorexia, nausea, perhaps occasional vomiting, and either diarrhoea or constipation. Sometimes there was a history of diarrhoea or dysentery during the previous few weeks.

Pyrexia of a mild type would now generally set in, associated with some chilliness and occasionally some shivering. The tongue was moist and often furred, but might be quite clean. Vomiting often occurred at this stage, and slight headache was common. "Pains all over" were sometimes mentioned in the early stage of pyrexia. Abdominal discomfort was usually present in the hepatic and epigastric regions. The pyrexial period in some cases lasted only one or two days, but was generally

* Delivered before the Medical Society of London, April-May, 1919.