February 27, 1890.

Sir G. GABRIEL STOKES, Bart., President, in the Chair.

The Presents received were laid on the table, and thanks ordered for them.

The Croonian Lecture was delivered as follows:—

CROONIAN LECTURE.—"The Relations between Host and Parasite in certain Epidemic Diseases of Plants." By H. MARSHALL WARD, M.A., F.R.S., late Fellow of Christ's College, Cambridge, Professor of Botany in the Forestry School, Royal Indian Engineering College, Cooper's Hill.

Received February 27, 1890.

(Abstract.)

Pointing out the intimate relations between the study of plant physiology and pathology, the lecturer briefly referred to the existing modes of classifying the diseases of plants, and the difficulties they involve. Broadly speaking, there are diseases due to soil, climate, and the influence of the non-living environment on the one hand; and those due to the attacks of living organisms (parasitic fungi, insects, &c.) on the other. Some interesting cases were briefly discussed, and the fact brought out that several causal factors co-operate in producing any disease.

With regard to fungus diseases, there are especial complexities, because we have to learn (1) the life history of the fungus, and (2) understand the biology of the host-plant, and this means we must (3) also discover what influences in each case are exerted by the variations of the environment (heat, light, moisture, &c.) in each case. Even then there is an unknown variable (4) in the internal changes going on in both the host and the parasite.

After reviewing, with the aid of illustrations and experiments, some of the principal functions of the normal tissues of a green plant, the effects of variations in temperature, intensity of light, amount of water in the air, &c., were discussed. The chief points are that under certain conditions, *e.g.*, a low temperature, feeble light, and when the atmosphere is saturated with moisture, the plant may be less able to withstand the inroads of a parasite, because its protective cell-walls are thinner and more watery, its cell sap abounds in sub-

stances like glucose, acids, and soluble nitrogenous matters, the protoplasm lining each cell is less capable of destroying substances which can injure it—its respiratory processes being enfeebled—and, in short, such a plant approaches the condition of a very young seedling, or a plant growing in the dark.

Experiments have proved that such plants not only offer less resistance to the hypha of a parasite, but the very conditions which cause the plant to abound in materials suitable to the fungus also suit the fungus itself.

Attention was then called to a peculiar parasitic disease, very common in green-houses, gardens, &c., in this country and elsewhere, and some cuttings of geraniums which had been wholly or partially destroyed by it were exhibited. One curious fact is, that this fungus causes a sort of rotten-ripeness of grapes on the Rhine, and that these mouldy grapes are those which are used to produce the finest wines in some of the districts: the explanation is that the diseased grapes undergo remarkable changes, by which the proportion of acid is reduced, and the must of the grapes rendered richer. But although in this case we utilise the effects of the disease-producing fungus, in other cases these fungi cause epidemic diseases of clover, rape, hemp, onions, hyacinths, and other plants.

The symptoms and progress of these diseases were described, the chief points being illustrated by lantern slides and actual specimens, of which there was a collection on the tables.

The fungus attacks the plant by destroying first its cell-walls, and then its protoplasm, cell by cell: this it effects by excreting a series of ferments or poisons. When it has destroyed the tissues, the fungus proceeds to extend more rapidly, and the destruction quickly advances. The fungus is as it were in the position of an attacking army, its weapons being these soluble ferments, or poisons, capable of dissolving the cell-walls and killing the living protoplasm in the cells.

The tissues of the host-plant, again, are in the position of a besieged army; the real fighting force being the protoplasm. The protoplasm is entrenched, so to speak, behind the cellulose cell-walls, and it has in its interior stores or reserves of food-materials which may be in a well replenished condition or the reverse. The hyphæ of the fungus overcome the cell-walls or out-works, by dissolving them by means of soluble ferments, and it will be intelligible that the thickness and solidity of these cell-walls are important in the matter; thin, soft, watery cell-walls being more easily penetrated.

Once inside the walls, the fungus-hypha is face to face with the real fighting contingent, however, the protoplasm; and the fact was insisted upon that circumstances affect the power of this protoplasm to cope with the poison which the hyphæ pour into it. So long as the

protoplasm can dispose of the small amounts of poison coming in from the hyphæ, by respiratory oxidation or otherwise, the hypha is debarred access to the cells, but immediately the poison succeeds in lessening or destroying the power of the protoplasm to control the cell-sap, the latter exudes through the permeable protoplasm, and suffuses the whole tissues with acid sap, containing just such food-materials as the fungus flourishes in. Consequently the latter spreads quickly, killing the cells more rapidly than ever, and soon destroying large tracts of tissue. This killed tissue turns brown, and we can consequently trace the progress of the disease by the spread of the discoloration. It was shown that the destructive power of the fungus concerned—*i.e.*, the capability of its hyphæ to produce the poisons—can be enhanced by culture in solutions of sugar, organic acids, and a little nitrogenous material and salts—just such a solution as is obtained in infusions of dead vegetable tissues; consequently the destructive power of the parasite increases as it feeds on the proceeds of destruction.

It has recently been discovered that the successive crops of spores of the fungus differ in infective power, and that, whereas the spores first formed may be unable to infect a living plant, those of the second or third generation can do so.

In conclusion, and passing over the observations and references to other diseases, there are four chief points to be considered in regard to the epidemic fungus-diseases concerned.

First, there is the healthy host-plant itself, which may be a more or less favourable object for the fungus. Secondly, there is the fungus, which may, or may not be, able to kill the living cells of the host. Thirdly, the influence of variations in the environment—especially low temperatures, want of light, and damp air—may so affect the host-plant that it is more easily and quickly infected by the fungus than was the case when its cell-walls were thicker and harder, and its protoplasm more capable of effecting certain processes of metabolism, and controlling the sap in the cells. Fourthly, the fungus also is capable of being rendered more formidable by variations in its environment, and especially by invigorating culture in suitable food materials.

Now when the external conditions are such that they favour the development of the fungus, while at the same time lowering the metabolic activity and respiratory power of the protoplasm, the conditions for an epidemic of the disease in question exist, and this is frequently realised in a dull, cold, wet July or August in this country. The point especially insisted on is not that any mysterious predisposition to disease is here manifest, but that the one plant—the fungus—is favoured by the prevailing conditions of culture more than the other—the host-plant. If we wanted to culti-

vate the fungus in one green-house and the host in another, each by itself, we should endeavour to provide the one set of conditions for the fungus, and another and very different set for the host.

Presents, February 27, 1890.

Transactions.

Adelaide :—Royal Society of South Australia. Transactions and Proceedings and Report. Vol. XI. 8vo. *Adelaide* 1889.
The Society.

Amsterdam :—Koninklijke Akademie van Wetenschappen. Verhandelingen (Letterkunde). Deel XVIII. 4to. *Amsterdam* 1889 ; Verslagen en Mededeelingen (Letterkunde). Deel V. 8vo. *Amsterdam* 1888 ; Ditto (Natuurkunde). Deel V. 8vo. *Amsterdam* 1889 ; Jaarboek. 1888. 8vo. *Amsterdam* [1889.]
The Academy.

Baltimore :—Johns Hopkins Hospital. Bulletin. Vol. I. No. I. 4to. *Baltimore* 1889. Johns Hopkins University.

Johns Hopkins University. Circulars. 1889. Nos. 74–77. 4to. *Baltimore;* Studies from the Biological Laboratory. Vol. IV. No. 5. 8vo. *Baltimore* 1889. The University.

Medical and Chirurgical Faculty of the State of Maryland. Transactions. 1889. 8vo. *Baltimore.* The Faculty.

Peabody Institute. Annual Report. 1889. 8vo. *Baltimore.*
The Institute.

Batavia :—Bataviaasch Genootschap van Kunsten en Wetenschappen. Notulen. Deel XXVI. Aflev. 4. Deel XXVII. Aflev. 2–3. 8vo. *Batavia* 1889 ; Register. 1879–1888. 8vo. *Batavia* 1889 ; Tijdschrift voor Indische Taal-, Land- en Volkenkunde. Deel XXXII. Aflev. 6. Deel XXXIII. Aflev. 2–4. 8vo. *Batavia* 1889 ; Verhandelingen. Deel XLV. Aflev. 1. 8vo. *Batavia* 1885 ; Plakaatboek. Deel VI. 8vo. *Batavia* 1889 ; Dagh-Register. Anno 1659. 8vo. *Batavia* 1889 ; De Derde Javaansche Successie-Oorlog (1746–1755). 8vo. *Batavia* 1889. The Society.

Koninklijke Natuurkundige Vereeniging in Nederlandsch-Indië. Natuurkundig Tijdschrift. Deel XLVIII. 8vo. *Batavia* 1889. With Deel XXII, and Deel XXIV. (Deficiencies.) 8vo. *Batavia* 1860, 1862. The Association.

Berlin :—Gesellschaft für Erdkunde. Verhandlungen. Bd. XVI. Nos. 8–10. Bd. XVII. No. 1. 8vo. *Berlin* 1889–90 ; Zeitschrift. Bd. XXIV. Heft 5. Bd. XXV. Heft 1. 8vo. *Berlin* 1889–90. The Society.