is much increased. On the other hand, if they are made to slope away from each other the glider becomes unstable.

9. Two square planes of equal size placed one behind the other at a small angle are less stable in the examples considered than a square equal in size to one of the two, but more stable than a single square whose side is equal to the total length of the glider formed by the pair.

10. A pair of unequal squares of which the smaller forms a rudder are more stable, in the examples considered, when gliding with the rudder behind than with the rudder in front.

11. In general, the stability is increased by making the moment of inertia as small as possible.

"Cultural Experiments with 'Biologic Forms' of the *Erysiphaceæ*."

By Ernest S. Salmon, F.L.S. Communicated by Professor H. Marshall Ward, F.R.S. Received December 2, 1903,—Read February 4, 1904.

(Abstract.)

In the introductory remarks the author points out that through specialisation of parasitism "biologic forms" have been evolved in the *Erysiphaceæ* which, both in their conidial (asexual) stage and ascigerous (sexual) stage, show specialised and restricted powers of infection. The powers of infection, characteristic of each "biologic form," are under normal conditions sharply defined and fixed, and hitherto the result of the experiments of numerous investigators—both in regard to the present group of fungi and to the *Uredineæ*, where the same specialisation of parasitism occurs—has been the accumulation of evidence tending to emphasise the immutability of "biologic forms."

The second part of the paper gives the result of cultural experiments with "biologic forms" of *Erysiphe Graminis* DC., carried out during the past summer in the Cambridge University Botanical Laboratory. It has been found that *under certain methods of culture, in which the vitality of the host-leaf is interfered with, the restricted powers of infection, characteristic of "biologic forms," break down.*

In the first method of culture adopted, the leaf, which was either attached to a growing plant, or removed and placed in a damp chamber, was injured by the removal of a minute piece of leaf-tissue. In this operation the epidermal cells on one surface, and all or most of the mesophyll tissue, were removed at the cut place, but the epidermal cells on the other surface (opposite the cut) were left uninjured. Conidia were sown on the cuticular surface of the uninjured epidermal cells over the cut. In a few experiments the conidia were

sown on the internal tissues of the leaf exposed by the cut, and these gave the same results.

Using this method of culture, over fifty successful experiments, of which details are given, were made. In these the conidia of certain "biologic forms" were induced to infect "cut" leaves of host-species which are normally immune against their attacks.

The experiments proved that the range of infection of a "biologic form" becomes increased when the vitality of a leaf is affected by injury, and also that species of plants "immune" in nature can be artificially rendered susceptible.

Further experiments showed that *the conidia of the fungus produced on a "cut" leaf are able at once to infect fully uninjured leaves of the same host-species.*

In other experiments, a method suggested by Professor H. Marshall Ward, with the object of avoiding lesion of the leaf, was adopted. Leaves were injured by touching the upper epidermis for a few seconds with a red-hot knife, and conidia were sown on the injured place. It was found that the cells immediately surrounding the place of injury were rendered susceptible to the attacks of a "biologic form" which is unable to attack uninjured leaves of the plant in question.

In the third part of the paper, dealing with general considerations, the following hypothesis is advanced as to the actual manner in which the injury to a leaf causes it to become susceptible to a "biologic form" otherwise unable to infect it. It is supposed that the leaf-cells of each species of host-plant contain a substance or substances—possibly an enzyme—peculiar to each species which, when the leaf is uninjured and the cells are vigorous, are able to prevent the successful attack of any mildew except the *one* "biologic form" which has become specialised to overcome the resistance. When the vitality of the leaf, however, becomes affected by injury, this substance is destroyed, or becomes weakened, in the leaf-cells in the neighbourhood of the injury, so that the conidia of *other* "biologic forms" are now able to infect them.

The author suggests that injuries to leaves, caused in nature by hail, storms of wind, attacks of animals, etc., may produce the same effect as the artificial injuries described above in rendering the injured leaf susceptible to a fungus otherwise unable to infect it. Conidia produced on these injured places would be able to infect uninjured leaves, and would spread indefinitely. Such may be the explanation of a common phenomenon—the sudden appearance of disease caused by parasitic fungi on plants hitherto immune.

A case is described which, it is believed, gives evidence that the injuries produced by *Aphides* caused leaves previously "immune" to become susceptible.

In the concluding remarks, reference is made to the antagonistic

forces concerned in the evolution of a "biologic form," viz., "specialising factors" and "generalising factors."

Attention is also drawn to the close parallel between (1) the behaviour of the fungus in the experiments in which the conidia were sown on the tissues of the leaf exposed by the cut; and (2) the biological facts obtaining in the class of parasitic fungi known as "wound parasites" (*Nectria*, *Peziza willkommii*, etc.), which are able to infect their hosts only through a wound.

"On the Origin of Parasitism in Fungi." By GEORGE MASSEE, Principal Assistant, Herbarium, Royal Gardens, Kew. Communicated by Sir WILLIAM T. THISELTON-DYER, K.C.M.G., C.I.E., F.R.S. Received January 11,—Read February 4, 1904.

(Abstract.)

Up to the present no definite explanation has been offered as to why a given parasitic fungus is often only capable of infecting one particular species of plant. This, however, is well known to be the case, for although the spores of fungus parasites germinate freely on the surface of any plant when moist, infection only takes place when the spores germinate on the particular species of plant on which the fungus is known to be parasitic. This apparently selective power on the part of the fungus I consider to be due to chemotaxis.

An extensive series of experiments were conducted with various species of fungi, including Saprophytes, facultative parasites, and obligate parasites, and the results are given in tabulated form in the full paper. The chemotactic properties of substances occurring normally in cell-sap were alone tested; among such may be enumerated saccharose, glucose, asparagin, malic acid, oxalic acid, and pectase. In those instances where the specific substance, or combination of substances, in the cell-sap assumed to be chemotactic could not be procured, the expressed juice of the plant was used.

These experiments proved that saprophytes and facultative parasites are positively chemotactic to saccharose, and this substance alone is sufficient in most instances to enable the germ-tubes of facultative parasites to penetrate the tissues of a plant, unless prevented by the presence of a more potent negatively chemotactic or repellent substance in the cell-sap.

As an illustration, *Botrytis cinerea*, which attacks a greater number of different plants than any other known parasite, cannot infect apples, although saccharose is present, on account of the presence of malic acid, which is negatively chemotactic to the germ-tubes of *Botrytis*.