contribution to our knowledge of the flora of China. The present part, like the preceding ones, is based primarily on a critical study of plants collected in western China by E. H. WILSON, but it includes also citations of collections made by HENRY, FAURIE, JACK, PURDOM, SARGENT, TAQUET, and others. Upward of 100 species and varieties new to science are recorded in some 40 different genera. The importance of the work lies, not only in the record of new plants, but also in the incorporation of much synonomy and bibliography from scattered publications.—J. M. GREENMAN.

NOTES FOR STUDENTS

Hereditary symbiosis.—One of the most remarkable of recent botanical discoveries, that of hereditary symbiosis between bacteria and seed plants, was made independently by MIEHE and VON FABER,[7] thus adding another to the notable list of great simultaneous achievements. As early as 1894 TRIMEN noted the persistent presence of small knotlike excrescences on the leaves of certain tropical Rubiaceae of Ceylon. In 1902 ZIMMERMANN noted the constant presence of bacteria in these structures, at least in four species from Java, whereupon he referred to them as bacterial knots (*Bacterienknoten*). Since ZIMMERMANN did not take up the question of the origin of the bacterial knots, VON FABER went to Buitenzorg in 1910 to make an extended study of them. A preliminary report of his early observations was made in 1911, and a full account followed in 1912.[8]

VON FABER investigated the symbiotic relations of five species of Rubiaceae, viz., *Pavetta indica*, *P. angustifolia*, *P. lanceolata*, *P. Zimmermanniana*, and *Psychotria bacteriophila*. In the closed buds the bacteria are found in resinous masses in among the leaf primordia. As the leaves develop, the bacteria enter them through certain precociously appearing stomata and pass into intercellular spaces, Soon there is differentiated in the leaf a special tissue composed of small cells rich in chlorophyll. Between these cells there develop capacious intercellular spaces, which the bacteria occupy henceforth. By the time the bacteria have occupied these spaces, the precocious stomata through which they entered the leaf become closed. From pure cultures of the host plants it was discovered that the bacterial tissue is derived from primordia which without the presence of the bacteria develop into a secretory reservoir, in which there accumulates a resin similar to that noted above as present in the bud. It is probable that the bacteria are attracted by this resin. Careful study of every stage in the life history of the host plants showed that the bacteria are always present. They become inclosed in the ovary at flowering,

[7] VON FABER, F. C., Über das ständige Vorkommen von Bakterien in den Blättern verschiedener Rubiaceen. Bull. Dép. Agric. Ind. Néerl. **46**: pp. 3. 1911. (See Bot. Centralbl. **119**:351. 1912.)

[8] ———, Das erbliche Zusammenleben von Bakterien und tropischen Pflanzen. Jahrb. Wiss. Bot. **51**:285–375. *figs. 7. pls. 3.* 1912.

and they enter the embryo sac through the micropyle. In seeds they occur constantly between the embryo and the endosperm. They are seen in young seedlings and in all later stages.

Careful study was made of the bacteria, both in the host plants and in artificial cultures. They were found to bear a close resemblance to the tubercle bacillus, both in structure and in behavior. Consequently VON FABER regards these organisms as members of the Mycobacteria, and he gives them the name *Mycobacterium Rubiacearum*, nov. sp. Of large interest also was the discovery that nitrogen is fixed in the artificial cultures of these organisms. VON FABER succeeded also in getting pure cultures of the Rubiaceae, the seeds being sterilized by placing them for 25 minutes in hot water at a temperature of 50°. The pure cultures grew far less vigorously than symbiotic cultures, and the leaves were lighter in color. It was observed also that nitrogen is fixed in the symbiotic cultures but not in the pure cultures, so that in nature these Rubiaceae can get their nitrogen supply directly from the air. Still further recalling the nutritive relations between the Leguminosae and their root bacteria is the fact that the bacterial tissue of the leaves of the Rubiaceae is rich in starch, which may serve the bacteria for food; there is evidence also of bacterial decadence, involution forms, and eventual phagocytosis. Pure cultures seem to indicate that each host species has its own bacterial "adaptation form."

MIEHE has also followed brief preliminary reports[9, 10] of his studies of hereditary symbiosis by detailed accounts.[11, 12] *Ardisia crispa*, one of the Javanese Myrsinaceae, has glandular thickenings on the leaf margins. These represent modified hydathodes and have commonly been regarded as albumen glands. It is now shown that these structures resemble ZIMMERMANN'S bacterial knots and are caused by bacteria. Furthermore the bacteria are present throughout the life history of *Ardisia*, and the details of bacterial entrance and subsequent behavior are astonishingly like those reported simultaneously in the Rubiaceae by VON FABER. The microorganisms enter the leaves through stomata, which later become closed. They were observed by MIEHE in the embryo sac, in the seed, and in the vegetation point of the seedling. Two species of bacteria have been isolated and are called *Bacillus foliicola* and *B. repens*. In old cultures there occur curved and branched involution forms. In most respects these organisms resemble VON FABER'S

[9] MIEHE, H., Die sogenannten Eiweissdrüsen an den Blättern von *Ardisia crispa* A.DC. Ber. Deutsch. Bot. Gesells. **29**:156–157. 1911.

[10] ———, Über Symbiose von Bakterien mit Pflanzen. Biol. Centralbl. **32**:46–50. 1912.

[11] ———, Die Bacterienknoten an den Blatträndern der *Ardisia crispa*. In Javanische Studien. Abhandl. Königl. Sächs. Gesells. Wiss. **32**:398–431. 1911.

[12] ———, Weitere Untersuchungen über die Bakteriensymbiose bei *Ardisia crispa* I. Die Mikroorganismen. Jahrb. Wiss. Bot. **53**:1–54. *pls. 2.* 1913.

Mycobacterium, except that there is no evidence of the fixation of nitrogen. Hitherto pure cultures of *Ardisia* have been unobtainable.

VON FABER[13] very recently has published further, checking up various minor points, and discussing MIEHE's work and his criticisms of the work of VON FABER. The most noteworthy result recorded in the latest paper is the success of the attempt to synthesize pure cultures of *Pavetta* and *Mycobacterium*. A symbiosis of the usual kind seen in nature resulted from the inoculation of the former by the latter. The luxuriant cultures thus arising seem to show clearly that VON FABER was working with the proper symbionts.—H. C. COWLES.

Stomatal activity.—ILJIN[14] has found that when the stomates of *Centaurea orientalis* are open, the guard cells have an osmotic pressure ranging from 85 to 108 atmospheres. When the stomates are closed, the guard cells have an osmotic pressure of 13–20 atmospheres. The osmotic pressure of the epidermal and parenchyma cells of the leaves vary little and approximate that of the guard cells with the stomates closed. Similar results were obtained for *Senecio Doria, Iris pumila, Eryngium campestre, Verbascum Lychnitis, Veronica incana*, and others. The guard cells with high osmotic pressure (stomates open) contain no starch, while the guard cells of low osmotic pressure (stomates closed) bear an abundance of starch. Conditions that bring about the closure of the stomates, darkness or excessive transpiration, will produce the condensation of the sugar to starch, accompanied by the great fall in osmotic pressure in about two hours. The reverse process of hydrolysis, accompanied by the great rise of osmotic pressure and opening of the stomates, is accomplished in about the same time under illumination and low evaporation power of the air. If these results are correct, we have here a great contribution to the mechanics of stomatal regulation. One would like to know the variation in the osmotic pressure of guard cells that show little stomatal regulation, as is true of certain swamp and xerophytic forms.

ILJIN[15] has also made an extensive study on stomatal regulation of transpiration. He used cuttings of plants in potometers and calculated the transpiration on the basis of the grams loss of water per 1000 $cm.^2$ per hour. While the potometer measures water absorption rather than loss, he believes that the two quantities are essentially equal in his work, since he has always discarded experiments in which wilting became noticeable. He ran his experiments in the open, either in an exposed place (the steppe) or in a protected region

[13] VON FABER, F. C., Die Bakteriensymbiose der Rubiaceen (Erwiderung und ergänzende Mitteilungen). Jahrb. Wiss. Bot. **54**:243–264. *figs. 3.* 1914.

[14] ILJIN, W. S., Die Regulierung der Spaltoffnung im Zusammenhang mit der Veränderung des osmotischen Druckes. Beih. Bot. Centralbl. **32**:15–35. 1914.

[15] ———, Die Probleme des vergleichenden Studiums der Pflanzentranspiration. Beih. Bot. Centralbl. **32**:36–65. 1914.