Staten Island, but the flora calls for a book of nearly 600 pages. About 80 per cent of the land plants occur also in the West Indies or southern Florida or both, while about 8.7 per cent of the total native flora is endemic, "there being 61 species in Bermuda or its waters not known to grow naturally anywhere else in the world." The representation of groups by the native species is as follows: Spermatophytes 146, Pteridophytes 19, Bryophytes 51, Lichens 80, Fungi 175 (at least), Algae 238, making a total of 709 species. The volume contains descriptions and illustrations of 519 species of Spermatophytes, Pteridophytes, and Bryophytes, and also accounts, not illustrated, of the Lichens, Fungi, and Algae.

The excellent text cuts, simple keys, and clear descriptions should make the volume a very effective introduction to an interesting flora.—J. M. C.

NOTES FOR STUDENTS

Prothallia and sporelings of lycopods.—Recent investigations have added greatly to our knowledge of some difficult prothallia and sporelings of lycopods and, with researches now well advanced, may make these phases of the life history as clear as in the common ferns. The Lycopodiales and Psilotales will be considered separately.

LYCOPODIALES.—Among the investigators who have studied the prothallia of *Lycopodium*, two have been preeminent both in field and laboratory work, namely, TREUB, who devoted his attention to the tropical species of Java, and BRUCHMANN, who studied species of the northern temperate zone. A third investigator of the first rank must now be added, the Rev. J. E. HOLLOWAY, who has discovered and studied the prothallia and sporelings of various New Zealand species of *Lycopodium*, so that species of the southern temperate zone are now represented. Three papers[3] have already appeared and the investigation is still in progress.

The introductory paper deals with *L. volubile*, *L. scariosum*, *L. densum*, *L. laterale*, *L. cernuum*, and *L. Billardieri*, all of which, except *L. cernuum*, are confined to the islands and countries of the south Pacific. He found prothallia of all except *L. densum*, so that 4 species are recorded for the first time, *L. cernuum* having been described by TREUB. Only a brief mention is made of the prothallia, the paper dealing, as its title indicates, with the comparative anatomy. The structure of the stele in young and adult plants is compared, and it is clearly shown that the radial type is primitive and that the banded type is derived from it.

[3] HOLLOWAY, J. E., A comparative study of the anatomy of six New Zealand species of *Lycopodium*. Trans. New Zealand Inst. **42**:356–370. *pls. 31–34.* 1909.

———, Studies in the New Zealand species of the genus *Lycopodium*. Part I. Trans. New Zealand Inst. **48**:253–303. *pls. 17, 18. figs. 102.* 1916.

———, Studies in the New Zealand species of the genus *Lycopodium*. Part II. Methods of vegetative reproduction. Trans. New Zealand Inst. **49**:80–93. *pls. 8, 9. figs. 24.* 1917.

The second paper deals with 11 species, including the 6 already mentioned, and adding *L. varium*, *L. Drummondii*, *L. fastigiatum*, *L. ramulosum*, and *L. Selago*. Since all these species, with the exception of *L. cernuum* and *L. Selago*, are rather unfamiliar to European and American botanists, the writer describes the habit, habitat, and environmental conditions. The ecological treatment, based upon an immense amount of field work, is particularly interesting, since some of the species are epiphytic and some terrestrial, and, of the latter, some belong to wet and some to dry habitats. Young plants and prothallia are not found in localities where adult plants are abundant, but in places like roadside cuttings where the soil has been disturbed. It is estimated that 15 years may elapse from the germination of the spore of *L. fastigiatum* to the fully developed prothallium; while species like *L. cernuum*, *L. ramulosum*, and *L. laterale* develop their more or less aerial and green prothallia in a single season.

Since the 11 species described by TREUB, BRUCHMANN, and others showed 5 distinct types of prothallia, it is surprising to find that among the various prothallia discovered by HOLLOWAY, no strictly new type has appeared. There are interesting variations, but the divergences are not sufficient to warrant an additional category. He believes that the *Lycopodium* prothallium is in a plastic stage of evolution, and that the various types have not been genetically distinct from a very remote period, but have diverged from the *L. cernuum* type, which now includes *L. inundatum*, *L. salakense*, *L. laterale*, and *L. ramulosum*, and is the only one which has shown a protocorm stage in the embryogeny. In *L. laterale* and *L. ramulosum* a protocorm grows out into a rhizome-like structure, the extension consisting largely of the swollen bases of the successive pairs of protophylls. The stem apex, with the root rather close to it, appears at the end farthest from the foot. Vascular tissue develops between the two apices, so that this region becomes the permanent axis of the plant. An examination of a large number of protocorms in various stages of development brings HOLLOWAY to the conclusion that the organ may be regarded as a physiological specialization to carry the plant over the dry season, and that too much phylogenetic significance should not be attached to it. Such an interpretation would accord, more or less, with BOWER's "gouty interlude" theory.

The vascular anatomy of the adult plant was studied in 11 species, and in 8 of these the sporeling was also available. In the sporeling there is, at first, a single crescentic group of protoxylem embracing a single group of protophloem; later, the structure becomes diarch, triarch, tetrarch, etc., by the splitting of protoxylem groups, so that the pattern assumes the radial arrangement, the banded condition coming later. In the adult plant, the radial type is found in *L. Selago*, *L. Billardieri*, and *L. varium;* a mixed type in *L. cernuum*, *L. laterale*, and *L. Drummondii;* and a parallel type in *L. volubile*, *L. densum*, *L. fastigiatum*, and *L. scariosum*. The general conclusion is that the various sections of the genus have not been separated from very ancient times, but that there are rather close interrelationships in which points of contact and divergence may be traced.

The latest paper, issued in July, 1917, deals with methods of vegetative propagation, both gametophytic and sporophytic. In prothallia, vegetative multiplication is accomplished by decay of intermediate parts of elongated specimens and by the isolation of branches in irregular forms. In the sporophyte, methods are more diversified. Bulbils, like those so well known in the *L. Selago* section, are common. In *L. cernuum* bulbils are formed which look exactly like protocorms, except that there is no foot; some of these have as many as 6 protophylls. Reproduction by root tubercles was found in *L. cernuum* and *L. ramulosum*. In the latter species gemmae are produced from cortical cells of the root and even detached leaves may bear bulbils resembling the protocorms of the species. Finally, the elongated protocorms of *L. laterale* and *L. ramulosum* may give rise to new plants by branching and by budding.

HOLLOWAY is continuing his studies and, with abundant material and opportunities for observation, will doubtless give us accounts of the internal structures of prothallia and protocorms and especially the development of the vascular system of the sporeling and its transition to the vascular system of the adult plant.

PSILOTALES.—With the exception of LANG's description of a single specimen, provisionally referred to *Psilotum*, the gametophytes of the Psilotales have been entirely unknown. It was expected of LAWSON that when he became established in the University of Sydney he would discover these gametophytes and give us an account, since the Psilotales are the only pteridophytes in regard to whose prothallia we have had no information. Two papers[4] have already appeared and another, dealing with the embryogeny, is in preparation. While *Tmesipteris* is epiphytic, notably on tree ferns, LAWSON also found it growing in soil, and it was in such a situation that he found prothallia in greatest abundance. *Psilotum* is more xerophytic, growing in clefts in the rocks, but it also thrives in moist situations, even in the spray of waterfalls, and in these moist places most of the prothallia were found.

In some features the gametophytes of the two genera are very similar. Both are subterranean and tuberous, light brown in color, and uniform in tissue, with no differentiation into vegetative and reproductive regions. An endophytic fungus is found in most of the cells, there being no localized fungal regions. Rhizoids come from all parts of the prothallium. Archegonia and antheridia are borne on the same individual and are not localized, but are scattered over all parts of the plant. The antheridia are spherical and produce a large number of coiled, multiciliate sperms. The archegonium consists of a

[4] LAWSON, A. ANSTRUTHER, The prothallus of *Tmesipteris tannensis*. Trans. Roy. Soc. Edinburgh 51:785–794. *pls. 1–3.* 1917.

———, The gametophyte generation of the Psilotaceae. Trans. Roy. Soc. Edinburgh 52:93–113. *pls. 1–5.* 1917.

venter which lies below the surface of the prothallium and a straight neck which projects as a short tube beyond the surface. The organization of the axial row was not worked out in detail. One figure shows an archegonium with an egg and two free nuclei in the neck canal.

In minor features the two genera differ. In *Tmesipteris* the archegonia are much more numerous than the antheridia, while in *Psilotum* the reverse is true. The archegonia and antheridia of *Tmesipteris* are about twice the size of those of *Psilotum*. The statement that the gametophyte generation of the Psilotaceae bears no structural resemblance to the prothallium of *Lycopodium* or *Equisetum* seems peculiar. We readily agree that there is no suggestion of *Equisetum* characteristics, but both the descriptions and the numerous excellent figures constantly remind one of *Lycopodium*, especially of the *L. Phlegmaria* type. LAWSON closes with the remark that no new facts were revealed which would discount the view, now generally held, that the Psilotaceae are more nearly related to the extinct Sphenophyllales than to any other known group of pteridophytes. This may be true, for the prothallia of the Sphenophyllales are entirely unknown and probably will remain so; but if they should be discovered, we should expect them to be of the *Equisetum* type. As far as the evidence of prothallia goes, we should guess that it indicates relationship with the Lycopodiales. The investigation of the embryogeny will be awaited with interest, since it will have a more definite bearing upon the problem of relationships.—CHARLES J. CHAMBERLAIN.

Photosynthesis.—BROWN and HEISE[5] have made a careful study of the experiments of various investigators on the relation of light intensity to photosynthetic rate. They conclude that "the published work on photosynthesis does not warrant the general conclusion that carbon dioxide assimilation in plants is proportional to the light intensity. Instead they indicate a progressively smaller augmentation of the rate of assimilation for each increase in light intensity. This decrease in rate of augmentation continues until a point is reached at which further increase in light produces no measurable increase in assimilation."

BROWN and HEISE[6] have also scrutinized the literature on the effect of temperature on photosynthetic rate and have come to the following surprising conclusions. The temperature coefficients (Q_{10}) lie between 1 and 1.4. They are smaller than those for most vital phenomena which have values agreeing with the Van't Hoff law. These coefficients are of a magnitude that indicates that photosynthesis is a purely photochemical process.

[5] BROWN, W. H., and HEISE, G. W., The relation between light intensity and carbon dioxide assimilation. Philippine Jour. Sci. **12**:85–95. 1917.

[6] ———, The application of photochemical temperature coefficients to the velocity of carbon dioxide assimilation. Philippine Jour. Sci. **12**:1–24. 1917.