into two nearly equal parts: Part I—"General morphology and physiology of bacteria and related organisms" and Part II—"Dairy and soil bacteriology." Realizing more than most authors the importance of making the student of bacteriology acquainted with the fundamental principles of morphology and physiology before proceeding to the applied bacteriology of agriculture, the authors have wisely devoted half of their book to this important subject.

This ground has been thoroughly covered in a distinctive and unusually instructive fashion. The refreshing originality of the "Vorlesungen," in the opinion of the reviewer, lies in the fact that this work closely followed the form of the author's own lectures in agricultural bacteriology. In this new work the subject-matter is handled in essentially the same order, and although the actual subdivision into lectures has been somewhat changed, the original logical method and lucid style are preserved. The seven chapters of the first part deal with the fundamentals in such a way that the student is well prepared for the specialized parts that follow, and students of other branches of bacteriology than agricultural will find this half of the text-book well worthy of study. Not only are bacteria discussed, but related microorganisms, yeasts, fungi and protozoa are included in relation to their development and activities. Subjects dealt with include morphology, development, classification, relation to environment, methods of cultivation, control and physiological activities and relationships. The chapter on the activities of bacteria and related microorganisms, comprising some sixty pages, is specially thorough, and covers such subjects as the cycles of the elements in an unusually clear manner.

Part II deals with dairy and soil bacteriology. Following a chapter on the microbiology of foodstuffs are chapters on the relation of bacteria and other microorganisms to milk, butter, cheese, water and sewage, manure and soils. It might be objected that the important subjects of bacteria in relation to animal and plant diseases have not been covered. Both these fields, however, represent more or less distinct lines of scientific specialization, in distinction to that which is usually understood as agricultural bacteriology, and are related more properly to veterinary medicine and general plant pathology. The authors have mentioned their bearing to bacteriological physiology in Part I, but have, as indicated, reserved Part II for dairy and soil problems. To these seven chapters have been dedicated, and the authors, in considering the various subjects, have followed the uniform plan of discussing first germ content, then bacterial activities and following up with the practical application in each case.

Throughout the book adequate references on all essential points are made to the special literature of the subject, and in this regard the authors have included the most recent investigations. Special mention must be made of the illustrations in this text-book, almost all of which are original. These consist of 66 figures and 10 full-page plates, of which 7 are colored. For originality and excellence of reproduction these are the best we have seen in bacteriological literature, and add greatly to the value of the work, which is to be highly recommended for student use.

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SPECIAL ARTICLES

A REMARKABLE DEVELOPMENT OF THE SPOROPHYTE IN ANTHOCEROS

THE genus Anthoceros is of special interest, as it more nearly approaches the Pteridophytes in the character of its sporophyte than does any other Bryophyte.

Of the American species of Anthoceros, *A. fusiformis* Aust., a very common species of the Pacific Coast, has much the longest sporophyte, which frequently reaches a length of two to three inches, or even more. The sporophytes are often produced in large numbers, so that a patch of fruiting plants looks like a tuft of fine grass.

The writer recently received from Dr. G. J. Peirce a number of specimens of *A. fusiformis* collected near Carmel, California, which showed a development of the sporophyte far exceeding anything hitherto recorded, so far as he is aware.

Some of these were full six inches (16 cm) in length, and were still actively growing. This is nearly twice the maximum length, 9 cm, recorded by Howe[1] for this species, and much exceeds anything seen by the writer in many years' collecting of Anthocerotaceae in various parts of the world.

Not only was there a remarkable increase in length, but the sporophytes were notably thicker than the normal ones.

Sections of some of these enlarged sporophytes showed that spore-formation had been almost completely suppressed in the basal region and the outer green tissue was much more extensive than in normal sporophytes. Still more striking was the greatly increased size of the central strand of tissue (columella), which might almost be denominated a simple vascular bundle.

The foot was also greatly enlarged and in two cases examined, the lower surface was almost completely exposed, and it is quite possible could absorb

[1] Howe, M. A., "The Anthocerotaceae of North America," *Bull.* Tor. Bot. Club, 24, p. 17, 1898.

water from below, without the intervention of the gametophytic tissues which had mostly withered. Indeed it looks as if these large sporophytes may have attained very nearly the complete independence characteristic of the Pteridophytes.

Usually *A. fusiformis* ripens its spores in the late spring, and both gametophyte and sporophyte dry up completely. The former, however, revives with the autumn rains. These large sporophytes were undoubtedly left over from last season and probably began to form some time in the autumn of 1922, as fertilization normally takes place within a short time after the first heavy rains, which last year fell early in October.

The writer visited the locality, San Jose Canyon, where these were collected. This is one of many small canyons south of Monterey, open to the ocean, so that they are invaded by the summer sea-fogs. There is a permanent stream, along whose banks fine redwoods, sycamores and alders were growing, as well as a rich growth of such liverworts as Fegatella and Marchantia, and several mosses.

The Anthoceros plants grew on low sandy banks, not far above the water level, and some of them showed fresh growth and bore a number of relatively young sporophytes.

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THE EFFECT OF THE REMOVAL OF THE MICRONUCLEUS

THE micronucleus in ciliates has commonly been considered to have solely a germinal function. In contrast with the macronucleus which, it is thought, serves for the upkeep of the individual, the micronucleus on the other hand is believed to provide exclusively for the maintenance of the race. This theory chiefly originates in applying to the *Ciliata* Weismann's hypothesis on the continuity of the germ plasm.

To ascertain the actual function of the micronucleus one must, of course, finally provide experimental means. This has been done by certain investigators (Balbiani, LeDantec, Lewin, *et al.*) who have removed the micronucleus from several ciliates, but this was accomplished by the excision of that part of the organism wherein the organelle lies. This method entails the burden of the regeneration of more or less of the organism and involves the possible removal of equally important stuffs.

The removal of the micronucleus from the fresh-water ciliate, *Euplotes patella,* has been successfully accomplished in more than fifty specimens by means of a mercury micropipette without causing any additional injury except the loss of a meager amount of cytoplasm immediately surrounding the removed organelle. *Euplotes* so operated upon have never lived longer than five days nor have they divided more than twice, so far as could be observed. A number failed to divide at all and lived only two days. The average life is about three days. Specimens which were fixed and stained showed an absence of the micronucleus, hence it was not regenerated. Individual controls from which cytoplasm of various regions of the organism or portions of the macronucleus had been removed formed vigorous races.

The few earlier reports, especially of Lewin and LeDantec, of ciliates having formed thriving races or having regenerated the micronucleus, after the experimental removal of this organelle, have not been substantiated by any of the experimental work done within the past dozen years. Several races of different species of ciliates have recently been intensively studied (Woodruff) and found to exhibit no morphological micronucleus. These races thrive apparently indefinitely. Conjugation either is not attempted or the conjugants always die. Two of these races have been known to arise from a micronucleate race which did conjugate normally. Woodruff (1921) has suggested that the macro- and micro-nucleus may have formed together in such races an "amphinucleus," which would be adequate for all life phenomena, but which would not permit the germinal chromatin in the micronucleus to become available for conjugation and endomixis. A morphological micronucleus would, accordingly, not be necessary for the vegetative life of the organism. The occurrence of such a nuclear change, however, is as yet not established.

If the micronucleus is solely germinal in function, it would be expected that a ciliate with no other injury than the loss of this organelle would give rise to a race asexually. The evidence from experiments on *Euplotes patella* goes to show that it can not continue to live and divide without the micronucleus. Just what rôle further than germinal the micronucleus plays is problematical. Hertwig, Calkins and others have maintained that the nucleus gives off certain formative substances, perhaps like enzymes, which are exhausted during cell-division. The results of the experiments thus far carried out on *Euplotes* suggest that the micronucleus performs some such rôle in the economy of this ciliate. The amount of the hypothetical substance present in the cytoplasm at the time of the removal of the micronucleus would determine the number of divisions possible before death. Division being impossible, death might ensue from a condition comparable to senescence in the metazoan cell or possibly from a surfeit of food which would normally be relieved by division.

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