what may be regarded as a laudable American aspect, it can scarcely be thought possible that he has not consulted, and consulted freely, every fascicle of Tschirch's "Handbuch" as it has been issued from the press. Though the present unfortunate war is teaching us how derelict we have been in making ourselves independent of Europe, so far as vegetable drugs are concerned, yet the pharmacognocist, above all, should ever be mindful of the inscription on the Flueckiger medal: *Scientia non unius populi sed orbis terrarum.* E. K.

Practical Oil Geology. By DORSEY HAGER. McGraw-Hill, New York, 1915. Pp. xii + 141; figs. 76, three being full page, and one plate. $2.00 net.

This handy pocket book puts the stock-in-trade of the petroleum geologist and engineer before the petroleum investor in a way that invites friendship. Further, it lays sound ideas of applied structural and stratigraphical geology before a class which is glad to substitute such revelations for the "luck" of the oil (or water) wizard.

While the space is so small as to call for brevity at the expense at times of clearness, the numerous excellent cuts—most of them evidently the author's—more than balance in field ingenuity and the applications of pure geology what may be wanting in the way of academic clarity of statement.

Only two or three proof errors appear in the text proper. An early second edition for so good a book on a timely subject seems sure, and in the reappearance no doubt there will be weeded out such oversights as: "Igneous rocks, or volcanics," p. 28; "a level line in the plane of the horizontal," p. 71; "curved axis," fig. 50 and p. 86; Comanchean equivalent to the whole Mesozoic, p. 38. Certainly the errors in Table XI. will not be recopied, nor perhaps that in averaging the viscosity of Oklahoma oils, especially the unfair inclusion of the high viscosity from Wheeler, Table VI. Convenience would be served by referring to a figure on a definite page rather than, say, "(See Fig. 19, Chapter III.)."

Useful adaptations for the layman are: Geological Names (Kemp); Mathematical Tables (Hayes); Tests for Oil (Woodruff); Favorable and Unfavorable Indications for Oil (Craig); Definitions of Formation and Member (Snyder). Other tables and data will serve more technical needs, and the cuts will doubtless be freely drawn upon by other authors.

The neat and convenient get-up, and strong, leather binding are characteristic of these publishers. CHARLES T. KIRK

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SPECIAL ARTICLES

ON THE RELATIVE NUMBERS OF RHIZOPODS AND FLAGELLATES IN THE FAUNA OF SOILS

THE investigations upon the protozoan fauna of the soil and its interrelations with the bacterial flora therein contained has opened a new field of exploration and suggested a new line of attack for the problem of "sick soils." The work of Russell and Hutchinson and their school indicates that the constituents of the protozoan fauna, notably the amœbas, affect appreciably the bacterial content of the soils they inhabit, and thus impinge upon some of the problems of fertility. This line of evidence has stimulated many preliminary investigations into the extent, distribution and qualitative make-up of the protozoan fauna of the soil. In many cases these attempts at the qualitative determination of these organisms have gone no farther than to record the relative numbers of the individuals belonging to the groups of rhizopods, flagellates and ciliates, with occasional questionable identifications of a few genera or more rarely still of species. The purely preliminary status of such investigations is readily inferred by those familiar with the fields of bacteriology, immunity and protozoology. Valid conclusions here can rest only upon a knowledge of the fauna which extends to an accurate determination of the species concerned and of their feeding habits or symbiotic relationships to the bacterial flora, which may be even more subtle than the gross phase of food relations.

One naturally recalls in this connection the similarities of *Entamœba coli* Lösch and *E. dysenteriæ* Councilman and Lafleur, and their long-standing confusion in the biological and medical literature, notwithstanding the very profound differences between them in their relations to their human host, the one a harm-

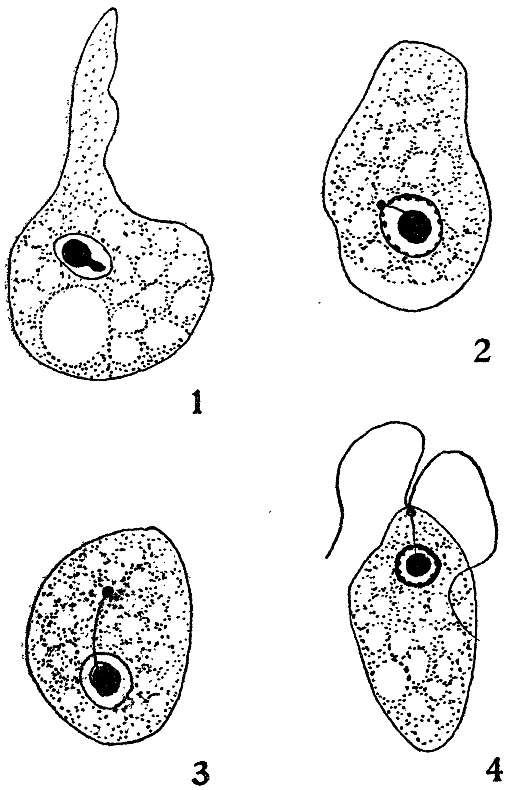

Fig. 1.

less parasite, the other a serious factor in disease. The conquest of amœbic dysentery was conditioned by the discovery of the differences between these two species, and the relations of each to their common host.

The relationship of *Entamœba buccalis* to Riggs' disease, or pyorrhea, is not only a problem in parasitism, but probably one also of the commensal relationship of this amœba and the bacterial flora of the gingival abscesses.

The remarkable and unique protozoan fauna of the first and second stomachs of the ox and other ruminants is composed of not less than 6 genera and 24 species living together in closest proximity in a common medium, but their relationships to it are not uniform. One species of the genus, *Diplodinium ecaudatum,* is, for example, exclusively a bacterial feeder (see Sharp, 1914), while others in the same genus feed indiscriminately on other components of stomach contents.

Indeed it is not impossible that, as in the case of pathogenic protozoa and bacteria, there will be found to be strains or pure lines within the species, whose ecological relationships may be so different among themselves as to lead to divergent conclusions regarding the species.

These facts lead to the inference that the mass treatment of the protozoan fauna of the soil without regard to its component species will tend to obscure and confuse its relationship to the bacterial and other flora, to the chemical conditions related thereto, and to the problem of sick soils and of fertility.

In a recent survey of the literature on the protozoa of the soil I have been struck by the great divergence of results at the hands of different investigators as to the nature and extent of the protozoan fauna discovered by direct examination and by culture methods. To the student of the ecology of the protozoa this divergence is to be expected in view of what is known of the seasonal fluctuations in numbers and kinds of protozoa in the population of reservoirs, ponds, lakes and streams. Adjacent bodies of water may have a very different seasonal history in these respects as I have shown (1904, 1908) with regard to the plankton of the Illinois River. Furthermore these minute organisms are very susceptible to infinitesimally small doses of certain mineral salts, notably copper sulphate. A treatment of a reservoir with this salt to the amount of only one part to ten million by weight will completely kill out most flagellates having chlorophyll in any of its forms in their organization and result in a total reorganization of the microfauna and microflora of the body of water thus treated, which persists for several months at least. Add to the seasonal fluctuations in heat and moisture and the local differences in chemical composition, the access of adventitious substances in rainfall, tillage, fertilizers, flood waters and seepage, and it is not strange that the protozoan fauna lacks uniformity. The chemical decompositions in the soil itself, its gaseous content, the antagonisms of certain salts, the demands upon the soil by its superterranean flora, the fluctuating bacteria and molds, the ravages of nematodes and the toxin and excreta of all of the organisms living therein and thereon, all form a part of the agencies potent in modifying, stimulating or depressing the protozoan fauna as a whole, and its several elements differentially.

One of the principal points brought out by recent investigations has been the relative numbers of flagellates and amœbas, the main interest centering in the latter because of their possible action as bacterophages of bacteria active in fixation of atmospheric nitrogen. The late C. H. Martin, whose death at the Dardanelles is an irreparable loss to the science of protozoology, has shown (1912) that one flagellate, *Monas termo* Ehrbg., is associated with the occurrence of certain "sick soils" in Great Britain, but little precise work has been done as yet elsewhere upon the flagellates of the soil.

Two papers published recently are typical of the divergences of results with respect to the relative abundance of amœbas and flagellates in the normal fauna of soils. Cauda and Sangiorgi (1914) in soils from rice localities find that amœbas are the prevailing forms, were present in all localities, and were exceeded in numbers by the flagellates in one case only. Flagellates together with the ciliates were sometimes entirely absent. On the other hand, Sherman (1914) concludes that the active protozoan inhabitants of most soils are probably restricted to the flagellates, that they constitute the greater portion of the protozoan fauna of the soil, and that the amœbas do not ordinarily occur in numbers nearly as great as do the flagellates. Both of these conclusions may well be correct *for the soils examined,* but I wish to cite facts which necessitate caution in making sweeping conclusions from such data and to set forth a new factor not as yet considered, in so far as I can infer from the literature, by any investigator of soil protozoa. The absence of its consideration tends to weaken or possibly even to vitiate conclusions as to relative numbers of amœbas and flagellates.

Certain investigations carried on in my laboratory by Dr. Charlie W. Wilson (1915) on the life history of a soil amœba have a direct and, it seems, an important bearing on this problem of the seeming relative numbers of amœbas and flagellates. I use the term "seeming" advisedly for the investigations prove that the common soil amœba, *Nægleria gruberi* (Schardinger), has a biflagellate phase, and enflagellates and exflagellates rather quickly on slight provocation under the conditions of laboratory culture. Not only do single individuals undergo these transformations but the whole mass of the culture may do so. The bearing of this fact upon the reported difference in the flagellate and rhizopod components of the protozoan fauna of the soil is self-evident.

This amœba (Fig. 1) is a small organism ($8\,\mu$ to $30\,\mu$) with one broad blunt pseudopodium or sometimes several blunt ones, and one subcentral nucleus. When it enflagellates the karyosome sends out a chromatic process (Fig. 2) which traverses the nuclear membrane, forms a marginal blepharoplast, and emerges as two long flagella (Figs. 3, 4). The body assumes a rigid asymmetrically curved shape and the organism swims away in the typical spiral course. When it exflagellates the flagella shorten and thicken and retreat into the cytoplasm and the blepharoplast returns to the karyosome within the nucleus. It takes about 70 minutes for a culture of amœbas to become one of flagellates, while the reverse process is somewhat longer and less uniformly followed by the individuals in the cultures. The addition of water, or fresh culture medium (filtered and sterilized soil and manure infusion) or the access of air, tends to induce enflagellation, but exflagellation is less definite in response to their opposites. Fission, budding, encystment, excystment and chromidial extrusion occur frequently and rather quickly.

These processes and the flagellate stage are evidently adaptive phenomena fitting this organism to a life in the soil with its vicissitudes of fluctuating food supply, alternations of drouth and moisture, and changing chemical and physical conditions.

This amœba was recovered by Wherry (1913) from the water-supply of the adjacent city of Oakland, California, but it is primarily, in our experience, a soil amœba, found in undisturbed alluvial soil along Strawberry Canon on our campus, in garden soils and appears to have its maximum abundance at a depth of about four inches, though it was also recovered on our campus from clay and rock talus *in situ* in the sides of the excavation for the Sather Campanile to a depth of over twenty feet. It has also been found in cultures from various ranch soils from the central valleys of California.

It is not distinguishable by any morphological characters from a species described by Schardinger (1889) as *Amœba Gruberi* from human feces in a case of dysentery at Vienna, Austria. There is evidence that this author used pure culture methods. It is possible, however, that the cysts might have taken in food or water and have passed intact through the digestive tract and then have been recovered from the feces in the culture, but contamination from dust or water are equally open as possibilities. All of these facts taken together lead to the inference that this amœba, *Nœgleri gruberi* (Schardinger), may have a wide distribution in the soil and to be cosmopolitan in its occurrence. If this proves to be the case, or if other amœba of the soil have similar flagellated stages, it is obvious that future investigations of the relative distribution of amœbas and flagellates in the soil should be so conducted as to avoid the complications in interpretation and conclusions involved in the Jekyll-and-Hyde life history of this organism.

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THE NATIVE HABITAT OF SPONGOSPORA SUBTERRANEA

The discovery of *Spongospora subterranea,* the powdery scab organism, on recent importations of potatoes from Peru by the Department of Agriculture has furnished important evidence bearing on the question of the origin of this parasite. *Spongospora* is widely distributed in Europe and within the last three or four years has established itself in several widely separated localities in the United States and Canada, but the problem of its origin has remained unsolved.

Kunkel's[1] recent work on *Spongospora* has demonstrated that a very intimate relation exists between the host cells and the parasite.

[1] Kunkel, L. O., "A Contribution to the Life History of *Spongospora subterranea,*" *Jour. of Agr. Research,* 4: 265–278, Pls. XXXIX.–XLIII., 1915.