istry since 1898, and acting-president since 1911, has been elected president of the university. William H. Whitcomb has been advanced from associate professor to professor and head of the department. James E. Egan, Ph.D. (Illinois, 1912), has been elected assistant professor to fill the vacancy caused by the resignation of Harvey C. Brill, Ph.D. (Michigan, 1911), to enter the government service in the Philippine Islands.

Dr. Geo. T. Hargitt, instructor in zoology at Northwestern University, has been appointed assistant professor of zoology at Syracuse University to fill the position made vacant by the transfer of Dr. Blackman to the School of Forestry.

Mr. Maurice Picard, M.A. (Columbia, '11), has been elected assistant professor of botany in Middlebury College.

At the University of Wyoming Mr. C. J. Oviatt, of the Michigan Agricultural College, becomes extension professor of agriculture and state leader in farm management and demonstration; Mr. A. E. Bowman, of the Utah Agricultural College, becomes extension professor of agriculture and assistant state leader in farm management and demonstration; research chemist, S. K. Loy, becomes professor of chemistry and research chemist; engineering chemist, Karl Steik, becomes assistant professor of chemistry and engineering chemist.

Mr. H. Clay Lint, of the Kansas Agricultural College, has accepted the industrial fellowship in plant pathology recently established in Rutgers College. He will begin work on July 15.

The General Board of Studies of Cambridge University have made the following appointments: Dr. Baker to be Cayley lecturer, and Dr. F. H. A. Marshall to be university lecturer on animal physiology, each for five years; and Mr. F. J. M. Stratton, M.A., Caius, to be university lecturer in astrophysics until March 31, 1918.

Professor Emil Abderhalden, professor of physiology in the University of Berlin, has declined the call to Vienna as the successor of Professor Ludwig.

DISCUSSION AND CORRESPONDENCE

THE COMPLEXITY OF THE MICROORGANIC POPULATION OF THE SOIL

Mr. E. J. Russell, of Rothamsted Experiment Station, has contributed a very interesting article in Science, under date of April 4, 1913.

In his opening sentence Mr. Russell says:

> During the last few years a series of experiments have been carried out in this laboratory by Dr. Hutchinson and myself which we can only interpret as showing that bacteria are not the only active inhabitants of the soil.

I write to say that I agree with this conclusion. I also agree fully with most of his statements of fact in paragraphs 1, 2, 3, 4, 5, and 6, and also with his paragraphs 7, 8, 9 and 10—in so far as they apply to the results obtained, though of course I can see no necessity of assuming that the protozoa constitute the "limiting factor" which is extinguished through partial sterilization. Mr. Russell is possibly right when he says:

> It is evident that the factor limiting bacterial numbers in ordinary soils is not bacterial, nor is it any product of bacterial activity, nor does it arise spontaneously in soils.

Though from their experiments, I see no necessity of assuming that the protozoa bring about this limitation.

In my article entitled "Interpretations of Results Noted In Experiments Upon Cereal Cropping Methods After Soil Sterilization," in Science, under date of February 10, 1912, I called attention to the thought that it might clarify matters to see what would happen in the case of "actual sterilization" of the soil.

I now call attention to the fact that in the Russell-Hutchinson experiments the sort of sterilization mentioned as being "partial" is just as liable to be effective against a large number of saprophytic fungi as it is to be effective against encysted amœboid types and that such saprophytic or semi-saprophytic fungus organisms are known to be as great reducers of organic matter, at least in its preparatory stages for bacterial activity, as some of the bacteria themselves.

If Messrs. Hutchinson and Russell are only

interested in finding out what limits the activity of the bacteria in the soil, then they and I are working upon two different problems. It would appear, however, that they wish to find out what it is that limits the bacterial activity in order that they can say that when this bacterial activity is limited there is a lessened ammonification, so that they may make the further assumption that when there is lessened ammonification there is of necessity a lessened yield of grain on the soil. In other words, they would account for the lessened or deteriorated grain product on such soils. In their regular reports in the *Journal of Agricultural Science,* they have actually made such thought transfers.

We have gone at the problem more directly in our experiments with the purpose in view of ascertaining what it is that tends to limit the grain production or to bring about deteriorated grain on fertile soils, and in doing so we have found that if we bring about rather perfect sterilization in potted soils, the limiting factor on grain production is done away with, provided we do not reintroduce it by means of internally infected seeds or other wheat disease-producing matters. Bacteria and amœbæ do not seem to play any primary part in this problem of deteriorated cereal crops.

The chemists have so thoroughly filled our minds with their belief that improvement in grain production or deterioration in grain production can only be accounted for because of modified elements of plant food that it would seem that some bacteriologists are coloring much of their work with an attempt to prove that bacteria are necessary to bring about those modifications which the chemists assume to take place.

The peculiar thing which our experiments make plain is that when we have a purified seedling placed in a purified soil, they show no element of weakness or tendency to deteriorate. Furthermore, our experiments do not show any particular necessary relationship associated with ammonification and such plant production. Deterioration takes place regardless of the presence or absence of high ammonification. We find, in ordinary soils, that a rather poor soil can produce perfect wheat seeds if free from parasitic organisms. We find also that a rich soil can not produce perfect wheat, regardless of its fertility and the amount of ammonification, if certain organisms are present in the soil or the seed.

Finally, I agree with Messrs. Russell and Hutchinson that microorganic population of the soil is "very complex," and would call their attention to the fact that in order to produce wheat on certain kinds of soil they will have to find types of amœba or other microorganism which will be capable of eating some very large fungi endways. Though we have checked up much of the work on soil toxines and gone into the bacterial proposition very carefully, especially with regard to ammonification, I yet must say that I am unable to find any cereal crop-limiting factors of any importance associated either with indefinite toxic substances or with the activity of bacteria. Having a given amount of available fertility, the plants get along. We have, however, found that there are at least one or more species each of the following mold-like fungi which, when in the soil, are real cereal crop-limiting factors: *Fusarium, Alternaria, Helminthosporium, Colletotrichum, Macrosporium* and *Ophiobolus.*

We find that most of these organisms are not only persistent in the soil, remaining there by way of the stubble and roots of their host plants, but may be introduced with the seed, fresh or improperly composted manures, etc., most of them being what may be spoken of as internal seed-infecting organisms. I would again call attention to what to me is an evident fact: that those who are working on the bacterial and toxine phases of the question of soil fertility will never have any results which they are justified in making use of until they are able to plant disease-free seedlings either in the soil or in their special cultures and to eliminate the disease factor in the soil. We have, of course, conducted many experiments, or I would not feel justified in making so strong statements as these. Were the problem of the soil fungi in wheat chopping less complex, I should long since have been giving out

much of the detail of the work at this experiment station. I will here, however, make one very interesting statement, based upon experimental results: In 1911 we had made many plantings of what we call "agar purified wheat seedlings" placing these in soil which we found to be free from the sort of organisms which we find to inhabit the average seed grain of wheat. It is not an easy matter to get an agar purified seedling—one which will grow in an agar made of synthetic media to represent the soil, or whose food basis consists of soil solution, in such manner that neither bacteria, fungi, or other organisms are found to be present in association with the roots.

When we were finally able to produce such agar-purified seedlings, they have been transplanted. In one set of such plantings in 200 lots, the average crop of wheat from such purified seedlings was 11.07 heads per seed produced on an average of 17.24 stools per seed. The heads thus grown were of rather perfect form and gave an average of 21.8 grams of nice plump wheat per plant while an untreated seedling of the same pure-bred strain of wheat, selected to the same perfect form and planted on the same day on the same soil gave an average of 6.11 heads on 8.5 stools and an average of 4.7 grams of seed.

It would make this piece of correspondence too extended to give other data of other types of seedling purification, seed treatment and soil treatment. These will not be given until published in tabular form in our regular station bulletins, but I may say that we have found that in a soil which has sufficient fertility to produce a crop, bacteria do not appear to be particularly needed so far as that individual crop is concerned, while there are certain parasitic and semi-parasitic mold-lime organisms which love the soil and the seed which are particularly detrimental and represent the chief crop-limiting factor aside from mineral elements and atmosphere.

There was a time when the bacteriologists thought they could tell safe or potable water by making counts of the number of organisms present. So now, there seem to be quite a few who think they can tell a productive soil by the number of organisms that are present therein, or by the amount of ammonification that may be or may not be taking place therein. It does not seem to be true with regard to either potatoes, flax or wheat. It made a material difference what kind of organisms were in the drinking water, so also it makes a material difference what kind of microorganisms are in the soil, and I have been unable to find that the amœbæ or their allies are particularly harmful or beneficial as associated with wheat cropping. There may, however, be some destructive fellows among them.

In making these statements, I would, of course, not be misinterpreted as assuming that bacteria do not have a useful place in the formation of plant food in the soil, nor would assume that, to a certain extent, amœboid organisms may not in part affect this development, but after a very careful reading of "Investigations on Sickness" in soil by Russell and Golding in *Journal of Agricultural Science,* Vol. V., Part 1, and the report of Messrs. Russell and Hutchinson on "The Effect of Partial Sterilization of Soil on the Production of Plant Food," as well as their original article on the same subject, October, 1909, in *Journal of Agricultural Science,* Vol. V., Part 2, I am unable to see that their experiments in any way prove a relation between amœboid activity and bacterial inactivity, nor can I see that there is any justification in the assumption that their studies in sewage-sickness show any feature characteristic of cereal sickness in arable soils. A sewage-logged soil is, at best, a poor analog of a cereal-sick arable soil. While no one can doubt that bacteria are the chief active agents in the preparation of plant foods from the rough organic remains of ordinary cropping refuse, that is one problem, and crop deterioration, as such, is another, which is superimposed upon the primary conditions of soil fertility. The crop deterioration problem is probably a problem of crop sanitation as involved in infectious disease.

H. L. Bolley

North Dakota Agricultural College,
May 15, 1913