cient for the cereals. Leguminous plants must therefore obtain nitrogen from some source, or under conditions that are not available for the cereals.

These facts are explained, in part at least, by recent experiments, which prove that the "tubercles" or "nodules" observed on the roots of leguminous plants, are caused by microbes, and that "the relation between the roots and the bacterial organisms is a true symbiotic one, each developing more vigorously at the expense of the other," and that free nitrogen is thus made available for the higher organism through the agency of the lower.

The experiments of Hellriegel leading to the discovery of these relations of mutual dependence, are noticed, and the experiments at Rothamsted in 1888 and 1889 with peas, vetches, lupins, red clover and lucern, which fully verify the results obtained by Hellriegel, are described in greater detail.

In these experiments the plants were grown in pots of clean white quartz sand, to which was added a small fraction of one per cent, of the ash of the plant under experiment, and this prepared sand was then sterilized by keeping it for several days at a temperature of 100° C. Distilled water was used in all cases to water the plants.

In each series, no other addition was made to one pot, while in two others the prepared sand was inoculated with a small quantity of the extract of a fertile soil. In a fourth pot plants were grown in a field or garden soil.

After about 4½ months, the yellow lupins in pot 1, in the prepared quartz sand alone, barely appeared above the rim of the pot, one plant being about 1½ and the other 2 inches high. In the inoculated quartz sand in pot 2, one plant was about 2 feet high, and the other 18 inches, both spreading beyond the width of the pot. One plant in pot 3, also in inoculated quartz sand, was more than 2 feet high, and the other little more than 8 inches.

The plants in pots 2 and 3 flowered and seeded, and they, in fact, made a better growth than the plants in pot 4 (in a soil from a field where lupins were growing), which were but 16 and 18 inches high, and less branching than those in pots 2 and 3.

There was little root development in pot 1, *and no root-tubercles could be found.* In pots 2 and 3 there was abundant root development, *and numerous root-tubercles*, exceeding in this respect the plants in pot 4.

Similar results were obtained with the peas and vetches, but the roots of the red clover and lucern were not examined, as the plants were kept for the second year's growth.

In all cases, luxuriant growth of the plants was coincident with the development of numerous root-tubercles, which were produced by the inoculation of a sterile quartz sand with microbes from a fertile soil.

The term *symbiosis*, as now used, is limited to the mutually beneficent relations of certain species living together in harmony, but the biological relations of mutual dependence presented by microbes and the plants growing in the soil, may extend to a series of organisms, each of which has its influence on the well being of the others.

The activities of microbes in soil metabolism are not limited to processes of putrefaction and nitrification. In the author's experiments with soil microbes they proved their ability to take their required supplies of lime and potash from solid fragments of gypsum and feldspar, and even from the glass tubes in which cultures were made, which were deeply etched by their action.

In the Rothamsted experiments vetches in a rich garden soil and lupins in a soil from a field where lupins were growing, did not grow as well as in sterile quartz sand containing a very small amount of the ash of the plants under experiment, and inoculated with the microbes contained in a soil extract.

The biological factors concerned in preparing plant food appear to be quite as important as the chemical composition of soils in promoting plant growth. The cereals with the microbes that find favorable nutritive conditions in the vicinity of their roots undoubtedly have an influence on the soil that aids in fitting it for the growth of luguminous plants with their symbiout microbes that appropriate free nitrogen, and thus add to the available stores of fertility.

The interdependent relations of soil microbes and plants of different habits of growth must be recognized as significant factors in vegetable nutrition, and a revision of the popular theories of soil exhaustion and manures is needed from the standpoint. The applications of science to agriculture will be best promoted by investigation relating to the life history of those organisms and their immediate and remote relations to the roots of plants of different species, and to processes of soil metabolism under different conditions.

In the light of recent experiments, Dr. M. T. Masters' prediction that farmers in the future will sow the germs of micro-organisms to increase the productiveness of their soils, does not appear to be a visionary one, and it is possible that the breeding of beneficial microbes may prove to be of as great interest to the farmer as the breeding of yeast now is in the manufacture of beer.

We must not, however, be misled by the plausible inferences that may be made from the evidence presented in regard to this recently discovered source of the nitrogen supply of leguminous plants under special conditions. It is not safe to assume that the nitrogen removed from the soil by crops, and by drainage, or otherwise, is fully restored by corresponding amounts derived from free nitrogen through the agency of microbes, or that this is the sole or even main source of the nitrogen of leguminous crops on average soils.

The Rothamsted experiments show that the previous accumulations of combined nitrogen in the soil must be the source of a large poportion of the nitrogen of leguminous crops, and that the frequent repetition of such crops does not prevent an appreciable diminution of the nitrogen of the surface soil.

The evidence thus far available seems to indicate that under ordinary conditions of farm practice the microbes concerned in working up the supplies of combined nitrogen in the soil are quite as important factors in the nutrition of leguminous plants as their symbiotic microbes that make free nitrogen available.

W. B. LAZENBY. (1)

Sherbrooke Exhibition.—This show seems, from the accounts in the papers, to have been successful, the attendance having been very large, whether on account of the attractions of the agricultural division or of the numerous "side-shows." I do not know. One point I must remark upon: there was no competition for the hundred dollars so liberally furnished by the Hon. Mat. Cochrane for the best *hacks!* How the Eastern-Townships' farmers can persist in driving those four-wheeled buggies of theirs over the lovely slopes of their farms, and along their pleasant grass-bordered roads, when they might enjoy a glorious canter on the backs of well bred roadsters, I never could understand. How, on earth can they expect the English officers who come over in hopes of picking up remounts for the cavalry to buy their horses if they will breed nothing but upright-shouldered harness-horses? Ride, gentlemen, do ride, if only for your health's sake. You will soon learn the difference between the two styles of horses, and breed in accordance with it.

(1) Rather stiff reading, but well worth an hour's study.

A. R. J. F.