

same as "free nitrogen"—that is, nitrogen not combined with any other substance. The term "combined nitrogen" means nitrogen combined with some other substance or substances. For example, potassium nitrate (saltpetre) is made up of potassium, nitrogen, and oxygen, and, therefore, the nitrogen of saltpetre is called "combined nitrogen" because it is combined with potassium and oxygen.

Now, so far as we know at present, plants in general take up their supplies of nitrogen as combined nitrogen (principally as nitrates), through the medium of their roots. But leguminous plants, that is, those which bear their seed in pods, such as beans, peas, clover, etc., possess the power of taking hold of the uncombined, or free, nitrogen of the atmosphere, and of manufacturing it into food for themselves.

If you pull up a white or Dutch clover plant, and examine the roots carefully, you will find, here and there, attached to the roots, minute rounded or oval-shaped bodies, called tubercles, or nodules. By experimenting with different kinds of leguminous plants, it was found that, under certain conditions, these nodules were formed abundantly, while under other conditions none were produced; and it was further noted, in connection with these plants, that those which produced nodules grew much more luxuriantly than those which did not. This fact led to the conclusion that the root nodules were in some way associated with the assimilation of free nitrogen by the plant. It was also discovered that certain forms of microbes, or bacteria, are always found in connection with these nodules, and, therefore, it is only reasonable to believe that the microbes in question are the agents which enable leguminous plants to feed upon the free nitrogen of the atmosphere. How the microbes thus assist the plant is not yet known. Three explanations have been offered:

(1) That, owing to the presence of these bacteria, the plant is able to fix the free nitrogen of the atmosphere, by its leaves; (2) that the nodule organisms (bacteria) become distributed within the soil, and there fix the free nitrogen, the resulting nitrogenous compounds becoming available as a source of nitrogen to the roots of the higher plant; (3) that free nitrogen is fixed in the course of the development of the organisms within the nodules, and that the resulting nitrogenous compounds are absorbed and utilized by the plant. The last

explanation seems the most reasonable, and is the one most generally accepted. According to this view, the root nodules are, as it were, the laboratories in which the bacteria work; and in which they manufacture the free nitrogen into compounds upon which the plant can feed.

An interesting point in this investigation was brought out by growing leguminous crops on soils that had been treated in different manners. On a soil which contained no nitrogenous material beyond what was contained in the seed sown, there were no root nodules formed, and the plants were very weak. On a similar soil that had been treated with a solution containing bacteria obtained from a fertile soil many root nodules were formed, and the plant growth was remarkably vigorous. Nodules were also formed when the plants were grown upon a fertile garden soil which contained an abundance of nitrogenous material. Thus it seems that a soil practically destitute of nitrogenous material may be made to grow leguminous crops successfully, by simply supplying or infecting it with the right kind of bacteria, which at once go to work to collect nitrogen for the plants. Why these bacteria refuse to perform the same kindly offices for other than leguminous plants is not known.

There is still another curious fact in connection with this matter. Different kinds of bacteria are found associated with different kinds of leguminous crops. Sir Joseph Gilbert, the noted investigator of Rothamstead, England, sums up as follows: The experimental results which have been brought forward clearly establish that there is a great gain of nitrogen under some conditions. It has also been clearly shown that due infection of the soil and of the plant is an essential to success. The evidence at the same time points to the conclusion that the soil may be duly infected for the growth of one description or some descriptions of leguminous plants, but not for some other descriptions. The field experiments on such plants at Rothamstead have further shown that land which is, so to speak, quite exhausted, so far as the growth of one leguminous crop is concerned, may still grow very luxuriant crops of another description of the same order, but of different habits of growth, and especially of different character and range of roots. This result, though undoubtedly more or less due to other causes also, is, nevertheless, in some cases doubtless dependent on the existence, the distribution,