Name: Date:

HANDS-ON ACTIVITY

Nitrogen Fixation

Many plants have mutualistic relationships with microorganisms in the soil. One example is the symbiotic relationship between legumes (plants belonging to the pea family, including beans, peas, peanuts, and alfalfa) and the soil bacteria *Rhizobium.* These bacteria fix elemental nitrogen (N_2), meaning that they convert N_2 in the soil into ammonia (NH_3). The NH_3 is further transformed in the soil into nitrate (NO_3), which is used by plants to make organic compounds, such as amino acids. The cycle continues when the nitrogen in these compounds is ultimately returned to the environment after the plant dies or is eaten.

MATERIALS

- microscope
- prepared slides of root nodules

The *Rhizobium* live in the root nodules of the plants. They provide critical materials for the plants, because plants cannot use nitrogen in its elemental form. In turn, the bacteria in the root nodules have protected access to water and nutrients. In this activity, you will use a microscope to observe one of these nodules.

PREDICT

What do you expect to see when examining the structure of a legume root nodule?

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PROCEDURE

1. Obtain a prepared microscope slide showing a section of a legume root nodule.
2. View the slide under the microscope, starting first with low power.
3. Look at all parts of the nodule section closely. Identify the cells containing the nitrogen-fixing bacteria, which will be found in the center of the nodule section.
4. Try to spot any vascular bundles in the nodule. These transport water and other molecules, and will likely appear as darkly stained ovals or circles slightly inside the outer wall of the nodule.
5. The outside layer of the nodule limits gas exchange with the environment. Take a look at this outside layer. Note how it may or may not differ from the other parts of the nodule.
6. Record your observations and draw detailed pictures of your root nodule section in the space provided in Data Table 1.

Name: **Date:**

DATA TABLE 1. OBSERVATIONS OF ROOT NODULES

Root nodule, viewed at low power:	**Root nodule, viewed at high power:**
Observations	**Observations**

Name: **Date:**

ANALYZE AND CONCLUDE

1. Describe the structure of the root nodule.

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2. How were the cells in the center of the nodule similar or different in appearance from cells on the outer edge?

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3. The chemical reactions carried out by the *Rhizobium* in the conversion of N_2 to NO_3 need to take place in a low-oxygen environment. How can the outer part of the nodule function to keep oxygen content in the nodule low?

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4. Many farmers rotate their crops, planting legumes in a field one year and other types of plants in the same field in following years. How might growing legumes in the field help the health of the next plants grown in the field?

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5. How does the nitrogen used by the plant get returned to the soil?

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6. Draw a model in your Evidence Notebook illustrating the role of *Rhizobium* in the nitrogen cycle. Show how this organism and legumes are involved in the cycling of nitrogen within ecosystems.

EXTEND

The soil around plants grown in the presence of *Rhizobium* should contain more NO_3 than the soil around plants grown in their absence. Use a soil-testing kit to determine the amount of NO_3 around a soybean plant grown with and without the bacteria. Also compare the plants. In the absence of *Rhizobium,* do the roots form nodules? How does *Rhizobium* affect the general health and appearance of the plant?