Royal Society of Biology

University of Southampton

Wonderseekers

Symbiosis, Legumes and Nitrogen

STUDENT WORKBOOK

Starter Activity

1. List some things that plants need to grow.

_____

_____

_____

2. List some things that animals need to survive.

_____

_____

_____

3. What does interdependence mean?

_____

_____

_____

4. How would you describe an ecosystem?

_____

_____

_____

5. Describe what a habitat is:

_____

_____

_____

_____

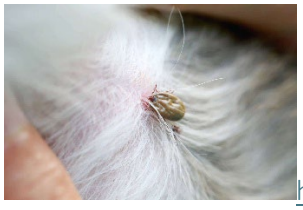
6. Look at the following descriptions and images. Decide who benefits in each relationship.

https://upload.wikimedia.org/wikipedia/commons/e/e3/Honey_Bee_collecting_nectar_from_a_flower_in_a_sunny_spring_day.jpg

a. A bee collecting nectar from a flower
   Who benefits? _____

https://www.yellowstonewildtours.com/2023/07/10/buffalo-birds-and-bison-a-yellowstone-sighting/

b. A bird eating insects off a buffalo's back
   Who benefits? _____



https://onlinefirstaid.com/ticks-and-the-danger-of-lyme-disease/

c. A tick feeding on a dog's blood
   Who benefits? _____

8. Can you think of another example where two living things helped each other? What did they do?

_____

_____

_____

Symbiosis:

Symbiosis is when two different species live closely together and interact in a long-term relationship. The word comes from Greek and means “living together.” These relationships often involve one organism living on or inside the other.

There are three main types of symbiosis:

- Mutualism – both organisms benefit.
- Commensalism – one benefits, the other is unaffected.
- Parasitism – one benefits, the other is harmed.

Note: Predator-prey relationships are *not* considered symbiotic because they are not long-term associations.

Mutualism

In mutualism, both species benefit from the relationship. A key example is the relationship between legume plants (like beans or peas) and Rhizobium bacteria.

Plants and animals need nitrogen to grow, but they cannot absorb nitrogen gas directly from the air. Rhizobium bacteria, which live in the soil, enter the roots of legume plants and form small swellings called nodules. Inside these nodules, the bacteria convert nitrogen gas into a form (like ammonia) the plant can use. In return, the plant provides sugars and oxygen to the bacteria.

This partnership helps both species and is a classic case of mutualism.

Other Examples of Mutualism:

Mutualism Pair	Organism A Benefits	Organism B Benefits
Bees and Flowers	Get nectar (food)	Get help with pollination
Clownfish and Sea Anemone	Protection from predators	Get cleaned. Leftover food
Oxpecker Bird and Zebra	Eats pests (ticks, insects)	Gets cleaned of parasites
Mycorrhizal Fungi and Plants	Receives sugars from the plant	Helps plant absorb water and nutrients

Commensalism

In this relationship, one organism benefits, and the other is not affected.

Example: Remora fish attach themselves to sharks and feed on leftover food. The shark doesn't gain or lose anything.

Other Examples of Commensalism:

Commensalism Pair	One Organism Benefits	Other Organism Effect
Remora and Shark	Free transport and food scraps	Shark is unaffected
Birds nesting in trees	Safe place to live	Tree is unaffected
Barnacles on whales	Get carried to find food	Whale is unaffected
Seeds on animal fur	Spread to grow elsewhere	Animal is unaffected

Parasitism

In parasitism, one organism (the parasite) gains while the other (the host) is harmed.

Examples include:

- **Tapeworms** in the human gut, stealing nutrients.
- **Mosquitoes** feeding on blood and spreading disease like malaria.

Other Examples of Parasitism:

Parasite and Host Pair	Parasite Gains	Host is Harmed
Tapeworm and Human	Nutrients from digestion	Human loses nutrients
Mistletoe and Tree	Water and nutrients	Tree may be weakened
Lice and Humans	Blood for survival	Itching, skin damage
Mosquito and Humans	Blood, spreads parasites	Risk of diseases (e.g., malaria)

Match the Terms. Draw lines or number each definition:

Term	Definition
Mutualism	A. One organism benefits, the other is harmed
Commensalism	B. Both organisms benefit
Parasitism	C. One benefits, the other is unaffected

Examples

Give your own examples or use ones from class:

- **Mutualism:** _____
- **Commensalism:** _____
- **Parasitism:** _____

Vocabulary Review

Write a short definition in your own words:

Word	Definition
Organism	_____
Resource	_____
Competition	_____
Symbiosis	_____
Mutualism	_____
Commensalism	_____
Parasitism	_____
Host	_____

Write whether you think these relationships are mutualism, commensalism, or parasitism. (Hint: it may be worth researching which organisms you are unsure of)

1. Mosquitos and humans _____
2. Honeyguide bird and badger _____
3. Orchids and trees _____
4. Lice and human _____
5. Tapeworm and mammal _____
6. Brown-headed cowbird and songbird _____
7. Mistletoe and hardwood _____

Legumes and Nitrogen-Fixing Bacteria

Think back to when you wrote down what plants need to grow.

Did you include minerals and ions in your list? Plants need minerals like nitrogen, potassium, and phosphorus to stay healthy. These are often added to the soil using fertilisers. But some plants, like legumes, are special—they get nitrogen in a different way. They form a mutualistic relationship with bacteria in their roots, which helps them use nitrogen from the air.

Legumes grow special structures called root nodules on their roots. Inside the nodules live nitrogen-fixing bacteria that convert nitrogen gas (N_2) from the air into ammonia (NH_3)—a form of nitrogen the plant can use. In return, the plant provides the bacteria with sugars and oxygen.

The nodules may appear pink inside. This is because of a molecule called leghaemoglobin. Just like humans have haemoglobin in their blood to carry oxygen, legume plants have leghaemoglobin in their nodules to help transport oxygen to the nitrogen-fixing bacteria.

What is nitrogen fixation?

_____

_____

What does the bacteria give the plant?

_____

_____

What does the plant give the bacteria?

_____

_____

What is this type of symbiosis called?

_____

_____

Fill in missing words:

Some plants called _____ have a special mutualistic relationship with _____-fixing bacteria that live in their _____. These bacteria turn nitrogen gas from the air into a form the plant can use to grow. In return, the plant gives the bacteria _____ made through photosynthesis.

What colour are active nitrogen-fixing nodules and what causes this colour?

_____

_____

What is the name of the protein in nodules that binds to oxygen and helps the bacteria function?

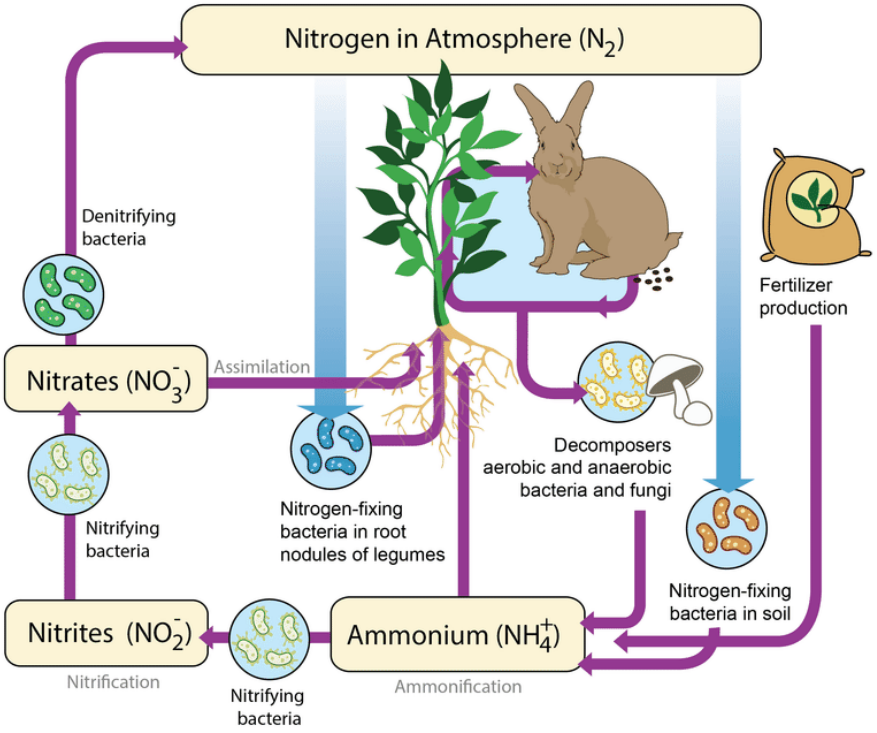
_____

_____

_____

_____

This is the nitrogen cycle. Plants and animals need nitrogen to survive. Nitrogen exists in many forms on Earth, but not all of them can be used directly. It must be converted into usable forms before living things can absorb it.



https://www.ck12.org/c/biology/nitrogen-cycle/lesson/The-Nitrogen-Cycle-Advanced-BIO-ADV/

Use the diagram above to help you complete this task:

Process	Letter
Nitrogen fixation	
Nitrification	
Assimilation	
Ammonification	
Denitrification	

A. Conversion of ammonia into nitrate by soil bacteria
B. Plants absorb nitrate from the soil to build proteins
C. Bacteria in roots or soil convert nitrogen gas (N2) into ammonia (NH3)
D. Decomposers break down dead matter into ammonia
E. Conversion of nitrate back to nitrogen gas by bacteria

Draw and label a simple diagram of a legume root system

Labels to include:

- Root
- Nodule
- Nitrogen-fixing bacteria
- Soil
- Nitrogen gas (N2)
- Ammonia (NH3)
- Sugars and oxygen

What do you think would happen if the nitrogen-fixing bacteria stopped existing?

_____

_____

_____

How does the symbiotic relationship between the legume and the bacteria benefit the ecosystem and humans?

_____

_____

_____

Investigation

Do you think the roots will have nodules? Write your prediction and explain why:

_____

_____

_____

Follow up Questions:

Plant Type	Successful growth?	Nodules Present?	Other Observations
Chickpea			
Lentil			
Lablab			

Based on your table, answer the following questions:

- Which sample showed the most nodules? _____
- What might the pink colour in the nodules tell us? _____
- What molecule has caused the pink colour? _____

Plenary:

Match each vocabulary word to the correct definition. You can draw lines or write the letter of the correct definition next to each term.

Vocabulary

1. Mutualism
2. Symbiosis
3. Nitrogen fixation
4. Nodule
5. Leghaemoglobin
6. Bacteria
7. Legume
8. Host
9. Parasitism
10. Commensalism

Definitions

A. A plant, such as a bean or pea, that forms a relationship with nitrogen-fixing bacteria.
B. A protein found in root nodules that helps control oxygen levels for nitrogen fixation.
C. When two organisms live closely together and interact.
D. A type of symbiotic relationship where one organism benefits and the other is unaffected.
E. The process by which certain microorganisms convert nitrogen gas from the air into a usable form for plants.
F. A relationship where one organism benefits while the other is harmed.
G. A small swelling on a plant root where nitrogen-fixing bacteria live.
H. A single-celled microorganism; some live in nodules to help plants grow.
I. The organism that provides resources or support to another organism, often a parasite.
J. A type of symbiosis in which both organisms benefit.

Extension:

Choose one pair and explain the relationship in your own words:

_____

_____

Go Further – Extension Tasks

Farmers often rotate crops by planting legumes one year and cereal crops (like wheat or maize) the next.

Explain how this practice benefits the soil and the next crop without adding chemical fertilisers.

_____

_____

_____

Imagine you're designing an experiment to test how the number of nodules affects plant growth.

What would your hypothesis be?

_____

_____

_____

What would your variables be:

- **Independent variable:** _____
- **Dependent variable:** _____
- **Controlled variables:** _____

How would you ensure your experiment is fair?

_____

_____

_____