Lesson 11: The Nitrogen Cycle

☐ Getting Started

You have examined a number of critical cycles that maintain stability for Earth's plants and animals. **Equilibrium**, the condition of a system in which competing influences are balanced, is vital for cycles. Cycles and systems that lose equilibrium do not function properly.

Today you will take a closer look at the nitrogen cycle and its role in plant growth. Nitrogen is an important nutrient in fertilizer. **Fertilizer** is a compound or substance that supplies nutrients to plants or that improves/changes *soil fertility* (the soil's ability to support plants). It is commonly used in farming, gardening, and lawn care. As you work through today's lesson, consider how the nitrogen cycle can lose equilibrium and the effects this can have on the local environment, as well as further away.

Don't forget to check the containers for the "Observing Decomposition" experiment from Lesson 8 today. Record your observations.

Stuff You Need

- ✓ *Exploring Ecology* by Anna Engelke

Ideas to Think About

- If nitrogen is cycled through the environment, why is it often necessary to supplement nitrogen with fertilizer?
- How does knowledge inform responsible practices?

Things to Know

- **Soil fertility** is the abundance of nutrients in soil that is beneficial for the growth of producers.
- **Fertilizer** is a compound or substance that supplies nutrients to plants. It can improve or change soil fertility.
- An **equilibrium** refers to the condition of a system in which competing influences are balanced.
- **Leaching** is the loss of water-soluble plant nutrients from the soil, due to rain and irrigation.

- **Eutrophication** occurs when too many nutrients enter a body of water (often due to leaching and fertilizer runoff), aquatic plants grow too much, and plant overgrowth uses up the available oxygen in the water, causing fish to die.

☐ Reading and Questions

Read the "Nitrogen Cycle" section on pp. 15-16 in *Exploring Ecology*. (If you are using the online version, read pp. 16-18.) As you read about keeping the Earth fertile, consider the role of nitrogen and the nitrogen cycle, the importance of balance in regard to amounts, and the interaction of organisms, including yourself, with the environment.

Then read about fertilizers at the following link. Answer the questions.

Web Link:
https://www.movingbeyondthepage.com/link/9487/
https://www.movingbeyondthepage.com/link/9854/

1. Why is fertilizer considered necessary?

_____

_____

_____

_____

2. Is it possible to have too much nitrogen in an ecosystem? What happens?

_____

_____

_____

3. How does eutrophication demonstrate an aquatic ecosystem trying to restore equilibrium (balance)?

Activities

☐ Activity 1: The Nitrogen Cycle

Track the journey of a nitrogen atom as it moves through the nitrogen cycle. Click through the web link, then follow the directions on "The Nitrogen Cycle" activity page.

The Nitrogen Cycle
www.movingbeyondthepage.com/link/10015/ Navigate this interactive nitrogen cycle using the Play/Pause button, or click through it step by step with the Step buttons. Be sure to click on each image and text label for more information.

☐ Activity 2: Plant Food

Nitrogen leaves the soil in three main ways:

1. It is absorbed by plants (assimilated) during the nitrogen cycle.
2. It **leaches** (washes) out of the soil due to rain or irrigation.
3. It is changed into nitrogen gas and released into the atmosphere during denitrification.

Plants consume a great deal of nitrogen, as well as two other main nutrients: phosphorus and potassium. When plants require more nutrients than the soil can provide, farmers, gardeners, and homeowners turn to fertilizers. However, because excess fertilizer pollutes drinking water and causes eutrophication, it is important to use fertilizers sparingly and only when needed.

Find out more about fertilizers and how plants use nitrogen (N), phosphorus (P), and potassium (K). Use the links provided (or do your own research) to complete the "Plant Food" activity pages.

Note: On fertilizer labels, phosphorus may also be called *phosphate*, and potassium may be called *potash*.

How do nitrogen, phosphorous, and potassium help plants?

www.movingbeyondthepage.com/link/10016/

This is a quick overview of how plants use nitrogen, phosphorus, and potassium.

More About Nitrogen, Phosphorus, and Potassium

www.movingbeyondthepage.com/link/9972/

This link describes specific ways nitrogen, potassium, and phosphorus are used by plants to stay healthy.

Understanding Fertilizer Labels

www.movingbeyondthepage.com/link/9845/

This site will help you understand how to read a fertilizer label, and it explains how to calculate the amount of potassium, phosphorus, and nitrogen in a bag of fertilizer.

Nitrogen Fertilizers for Home Lawn Care

www.movingbeyondthepage.com/link/9844/

This website explains how nitrogen helps grass stay healthy. It also discusses quick versus slow release fertilizers, and the difference between organic and inorganic (chemical) fertilizers.

Quick vs. Slow Release Fertilizer

www.movingbeyondthepage.com/link/9846/

If you are not sure whether to recommend a slow or quick release fertilizer, scroll down to the center of this page for a table that compares the two options.

Organic vs. Non-organic fertilizer

www.movingbeyondthepage.com/link/9847/

If you are not sure whether to recommend commercial fertilizer or organic methods, this article details the pros and cons of each type.

☐ Wrapping Up

As you consider lawn-care practices, keep in mind the role of cycling matter and energy in an ecosystem. While lawns may or may not be considered an ecosystem, cycles are still occurring and you will want to keep in mind the importance of cycling energy and matter such as carbon dioxide, water, nitrogen, and even oxygen.

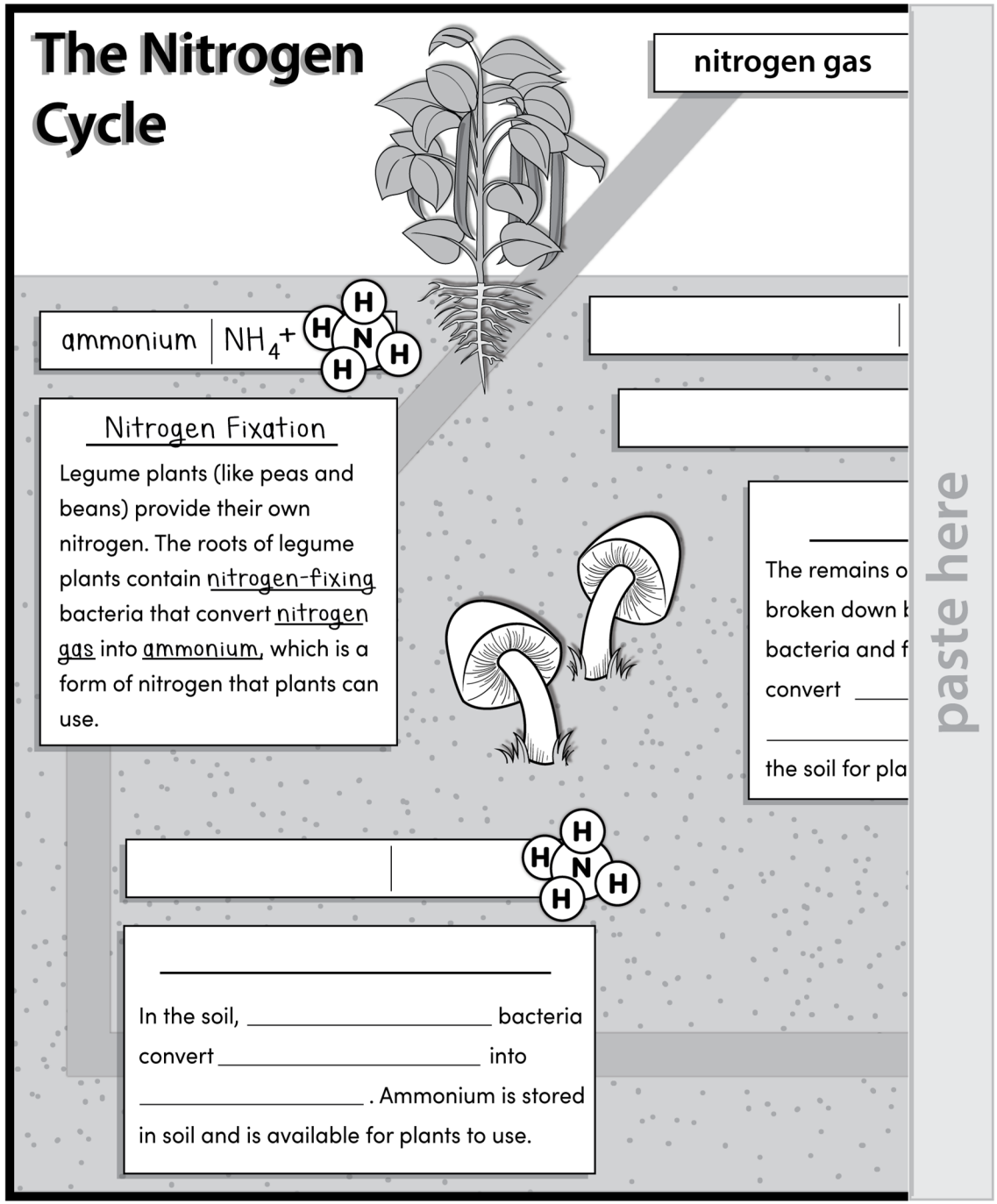
THE NITROGEN CYCLE

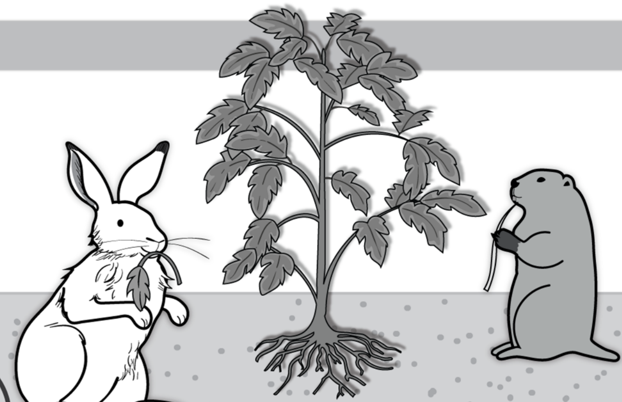
Directions: Fill in the blanks using the words from the word box. Words will be used more than once. Color the nitrogen (N) atoms blue, oxygen (O) atoms pink, and hydrogen (H) atoms green. Add arrows to show the flow of nitrogen through the nitrogen cycle. Use the web link to help you. The *nitrogen fixation* step has been done for you as an example.

word box

Molecules:	Forms of Nitrogen:
N_2	nitrogen gas
NH_4^+	ammonium
NO_2^-	nitrite
NO_3^-	nitrate
NH_3	ammonia

Stages:	Bacteria:
Nitrogen Fixation	nitrogen-fixing
Ammonification	nitrifying
Nitrification	denitrifying
Assimilation	decomposing
Denitrification	





____

…f dead plants and animals are …by ______________________ …ungi. These bacteria and fungi ______________________ into ____________ , returning nitrogen to …nts to use again.

____

Plants assimilate (absorb) nitrogen from the soil as either ______________ or ________________ . Animals need nitrogen too, and they get it by eating plants.

____

Some nitrogen is returned to the air. ____________________ bacteria convert ____________________ into ____________________.

____

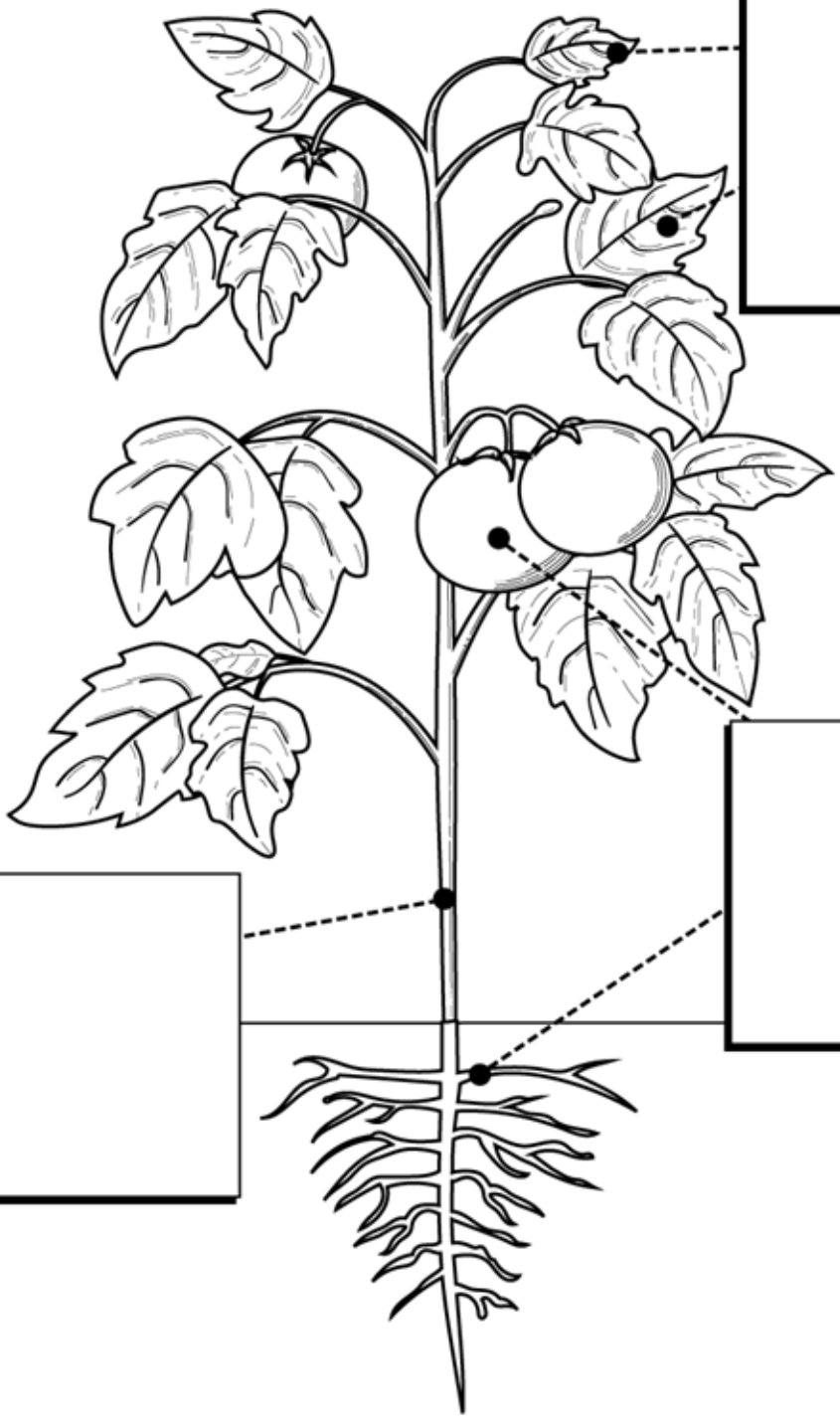
Ammonium can be converted to another form of nitrogen that is also used by plants. This process is called nitrification. During nitrification, ________________ bacteria in the soil convert________________ to ____________________ . But nitrite cannot be used by most plants. It must be converted into another form of nitrogen.

____

During the second step of nitrification, ________________ bacteria in the soil convert ________________ to ________________.

Plant Food

Directions: Identify which nutrient (potassium, phosphorus, or nitrogen) helps each part of the plant and explain what the nutrient does. Then answer the questions. Use the web links or your own research to help you.



1. How many pounds of each nutrient is in a 10-pound bag of 10-2-5 fertilizer?

   Nitrogen: _____ Phosphorus: _____ Potassium: _____

2. Many experts recommend a ratio of about 4-1-2 for lawns. This means that compared to nitrogen, there is 1/4 the amount of phosphorus, and 1/2 the amount of potassium. Which of these nutrient ratios would be a good choice?

   15-15-15 **30-10-5** **12-3-6**

3. Garden fertilizers often contain less nitrogen, more phosphorus, and more potassium than lawn fertilizers. Why do you think this is?

   _____

   _____

   _____

   _____

4. Which type of fertilizer would you recommend someone use for their lawn? Why?

   Organic or inorganic (chemical): _____

   _____

   _____

   Quick release or slow release: _____

   _____

   _____

5. Would you recommend getting a soil test before purchasing fertilizer? Why or why not?

   _____

   _____

6. Besides using store-bought fertilizer, what is a more natural way to provide nitrogen to a lawn?

   _____

   _____

Final Project: A Sustainable Farm (3 Days)

☐ Getting Started

For your final project, you will design a farm that incorporates the three major cycles you have explored in this unit. You will also take your unit test.

Don't forget to check the containers for the "Observing Decomposition" experiment from Lesson 8 over the next several days. Record your observations. When you have finished recording your seven days of observations, remember to complete the results page (page 2) for that activity.

Stuff You Need

- ✓ colored pencils or markers* (Activity 5 - optional)
- ✓ poster board or cardboard* (Activity 5 - optional)

Ideas to Think About

- How can Earth cycles be used to ensure the survival of artificial ecosystems such as farms and gardens?
- How does knowledge inform responsible practices?

Things to Know

- Sustainable farming methods allow a farm to work in harmony with the carbon, water, and nitrogen cycles.

Activities

☐ Activity 1: Study for the Unit Test

Review what you have learned in this unit in preparation for the test you will take tomorrow. Study the Unit Review Sheet in the following link (or located toward the beginning of the print version of this unit). Review the reading and questions pages you did for each lesson. Also look at the activities you completed in each lesson. Pay special attention to the carbon, nitrogen, and water cycles, and review how matter and energy flow through an ecosystem.

Unit Review Sheet
www.movingbeyondthepage.com/link/9988/

☐ Activity 2: Plan a Sustainable Farm

Imagine you own a small plot of land (2-5 acres). You want to use this land to provide food and/or income for your family. You also want your farm to be sustainable, meaning that you can raise healthy, productive plants and animals year after year. You have decided to begin planning your farm by researching sustainable farming techniques.

Sustainable farming methods help a farm work in harmony with the carbon, water, and nitrogen cycles. They support the carbon cycle by encouraging farmers to leave more organic matter to decompose in the field. They improve a farm's soil by supporting lots of bacteria, fungi, worms, and other organisms. Good soil, in turn, absorbs water better because roots, decaying plants, and worms make the soil crumbly instead of a hard mass of dirt. The soil has more nitrogen and other nutrients thanks to the extra organic matter and all those organisms. Done well, sustainable farming techniques keep plants healthier and resistant to disease because they have plenty of food and water. Some sustainable farming methods reduce the need for pesticides, too.

Research two or more sustainable farming techniques from the following list to incorporate into your farm. You can use the Internet or get books from the library (books on composting, gardening, and forest gardens should be easy to find). To research online, enter the name of the farming method as your search criteria. You could also add "how to..." or "benefits of..." to your search phrase. For example, to research hedgerows, search for "hedgerows" or "benefits of hedgerows." Look for results from universities (these links end in ".edu") and scientific/research organizations (these can be from the government, like the U.S. Department of Agriculture, or independent organizations like the Rodale Institute). Here is an example of a good source of information for hedgerows.

A Guide to Hedgerows
www.movingbeyondthepage.com/link/10005/ This link is from Oregon State University. It provides reasons why hedgerows are beneficial as well as guidelines for choosing plants.

Choose two or more of these sustainable farming methods to research and use on your farm:

- **Hedgerows:** These are rows of bushes or trees planted between fields. Hedgerows provide many benefits. They block wind, protecting plants and reducing water evaporation in soil; encourage insects and birds, which pollinate plants and eat bugs that attack crops; and if you plant berry bushes or fruit trees, they provide another food source.
- **Cover crops and crop rotation:** Crop rotation (planting a different crop each year in a field) helps prevent the soil from being depleted of nutrients. After the main crop has been harvested, cover crops are planted and are allowed to grow during the fall, winter, and early spring. Before a cover crop produces seeds, it is broken up and turned back into the soil, where it decomposes and increases the nutrients in the soil. Cover crops also prevent the soil from being eroded between plantings.
- **Rotational grazing:** In a rotation grazing system, a pasture is divided into sections. Animals graze in one small section for several days, and then are moved to a new section. This system keeps a pasture healthy by preventing overgrazing, which can kill grass and damage soil.
- **No-till farming:** Tilling a field means to break up and turn over the top 6-10 inches of soil before planting a new batch of seeds. Too much tilling increases soil erosion, kills helpful soil organisms, and eventually makes the soil hard and compacted. In a no-till system, farmers disturb the soil as little as possible by planting new seeds right over the stems and roots of the last season's crop.
- **Composting:** Organic matter (grass cuttings, vegetable scraps, dead plants) that is allowed to decompose turns into compost. Adding compost to soil improves its texture and nutrient level. Compost is commonly used in gardens but is valuable for farmland as well.
- **Intercropping:** This technique involves growing two or more crops in the same space. Intercropping allows you to grow more food in less space and control pests. For example, planting basil with tomatoes helps protect tomatoes from tomato hornworms. Crops should be from different plant families so that each crop use a different mix of nutrients.

- **Forest gardens or food forests:** Similar to intercropping, forest gardens involve planting many crops in the same space. In a forest garden, however, most of the plants are perennial (grow back year after year). You don't need to plant often after a forest garden is established. Forest gardens make use of the many layers of a forest by including plants of different heights. Think nut trees, fruit trees, fruit bushes, vine fruits, and perennial plants that live close to the ground, like herbs, strawberries, or asparagus.

Day 2

☐ Activity 3: Take the Unit Test

Take your unit test today.

☐ Activity 4: Choose Your Crops

You have already decided that you want at least two different crops, but no more than five. You have considered adding 1-2 animals, but you aren't sure yet. First you will brainstorm what you would like to grow. You can choose any mix of fruits, vegetables, nuts, grains, and animals. You can raise food to eat, food to sell, or both. Make sure the plants and/or animals you choose will work with the sustainable farming techniques you are using.

- **Plants:** Consider whether you want to use the land for planting vegetables, fruits, or traditional field crops like oats, corn, wheat, and soy. All of these products can be sold or eaten by your family. If you would like to grow fruit or nut trees, you can pretend the trees are mature and established. For example, maybe your farm already has a peach or apple orchard and you would like to add a small vegetable garden or a field of oats. You may also decide to grow something unusual like mint or sunflowers. Find out which nutrients your crops use most and if they require any special care.
- **Animals:** If you would like, you may decide to raise chickens, pigs, goats, or other animals as well. Chickens produce eggs, meat, and fertilizer. Goats, cows, and sheep produce fertilizer; they also provide milk that can be eaten, sold, or turned into cheese. Horses produce fertilizer as well, if you want a pet! Research how to raise your animals humanely and sustainably.

Make a list of the 2-5 plants you will grow. If you have decided to raise animals, list them as well. Now you are ready to sketch out a rough plan. On a piece of paper, draw

the layout of your farm (this doesn't need to be perfect — you will redraw it later). How many fields will you have? What will be planted in each field? If you are going to have a garden or an orchard, where will it be? Will you have hedgerows of bushes or trees? If you have animals, remember that they will need plenty of space to roam, and more than one pasture if you will be rotating where the animals graze.

NOTE: As you research your crops/animals, you are encouraged to consider issues like pesticide or chemical fertilizer use, how you could have access to any required equipment, whether you would need to hire extra workers to help you, or the effects the crops/animals you produce may have on the climate and the local environment. How might these issues influence which crops/animals you select?

☐ **Activity 5: Create a Sustainable Farm Display**

For the rest of today and tomorrow, create a display for your sustainable farm. You can design your display any way you wish. You may want to attach the different components to large pieces of poster board or cardboard, tape them to a wall, or simply set them out on a table in an organized fashion. Include these elements:

1. Large, detailed map of your farm's layout. Label the crops (or animals) in your fields. Briefly explain why you chose each one, and any specific nutrient or care requirements they have.
2. For at least two of your crops (or a crop and an animal), include a label explaining the sustainable farming technique(s) you are using. For example, if you have a field of corn, your label could read: "Crop rotation helps prevent the soil from being depleted of nutrients. This will be a corn field the first year, and a soybean field the second year. No-till farming prevents soil erosion and kills helpful soil bacteria, so I will not till the soil before planting the soybeans."

3. Diagram of the water cycle, and an explanation of how your sustainable farm incorporates the water cycle. For the diagram, you can copy the diagram from the *Exploring Ecology* booklet or create your own. You could include your plan for watering, or explain how you are improving your soil to increase its ability to absorb water. If you are planting a forest garden, your label could read: "My forest garden shouldn't need to be watered very often after it is established. I will help it conserve water by making sure the ground is covered with plants or mulch. Covering the ground prevents water from evaporating, and allows the soil to soak up more water when it rains."
4. Diagram of the carbon cycle, and an explanation of how your sustainable farm incorporates the carbon cycle. For the diagram, you can copy the diagram from the *Exploring Ecology* booklet or create your own. If you are growing a garden, your label could read: "Growing a garden supports the carbon cycle because plants absorb carbon. When my plants die and decompose, the carbon they store goes into the soil. Composting also supports the carbon cycle by putting organic matter back into the soil. I will start a compost pile and add the compost to my garden regularly."
5. Diagram of the nitrogen cycle (you can use the one you created in Lesson 11), and an explanation of how your sustainable farm incorporates the nitrogen cycle. If you have decided to use a cover crop in your field or garden, your label could read: "Cover crops from the legume family add nitrogen to the soil. After I have harvested my crops, I will plant a legume cover crop. Before it produces seeds, I will cut the cover crop down and work it into the soil or let it decompose naturally, disturbing the soil as little as possible. The nitrogen in the legume plants will be returned to the soil."

Be sure to do additional research for your display as needed. If you aren't sure how to incorporate the water cycle in a forest garden, for example, you can search for "water cycle in a forest garden" or "food forest and water cycle." To find the information quickly: skim the links that come up, choose the most promising link(s), and then skim the web page(s) until you locate the information you are looking for. You shouldn't need to read entire articles.

Day 3

☐ **Activity 6: Finish Your Sustainable Farm Display**

Continue creating the elements you didn't finish yesterday. When you are done, arrange them attractively on cardboard, poster board, a wall, or a table. Gather your family and invite them to visit your sustainable farm!

☐ **Wrapping Up**

If your family lives in an area where gardens are allowed, discuss implementing portions of your sustainable farm plan for your family.

Earth Cycles and Systems Test

Matching

Match each term with its definition.

1. _____ matter
2. _____ energy
3. _____ electromagnetic energy
4. _____ fixing
5. _____ leaching
6. _____ autotrophs
7. _____ heterotrophs
8. _____ decomposers
9. _____ cellular respiration
10. _____ food web
11. _____ photosynthesis

A. the loss of water-soluble nutrients from the soil due to rain or irrigation
B. organisms that break down dead or decaying matter
C. waves and rays (like heat and light) released by the Sun
D. sunlight powers this process that plants use to make carbohydrates (food)
E. these organisms cannot produce their own food
F. anything that has mass and takes up space
G. the process of changing a substance into a more biologically usable form
H. this process is used by cells to break the chemical bonds of molecules, thereby releasing energy the cell can use
I. the ability to do work
J. a graphical description of feeding relationships among species in an ecological community
K. these organisms make their own food

Ordering

12. Number these events to reflect how energy and matter move through the environment. Start with the Sun.

_____ Decomposers eat heterotrophs and autotrophs when they die, breaking down the organic matter so that it can be reused. However, energy that has been absorbed and transferred through autotrophs, heterotrophs, and decomposers is either used by the organisms or released back into the environment as heat.

_____ Autotrophs use light energy from the Sun, water, and carbon dioxide to make food (carbohydrates) for themselves. Where light is not available, some autotrophs use chemicals. Cells use the energy stored in carbohydrates to survive.

_____ Electromagnetic energy radiates from the Sun and reaches the Earth.

_____ Heterotrophs consume autotrophs, the products of autotrophs (like seeds and fruits), or other heterotrophs. Heterotrophs indirectly consume energy from the Sun by breaking down carbohydrates and other molecules from these organisms.

13. Number these events to reflect how water moves through the environment, starting with evaporation.

_____ Precipitation is absorbed and stored in the soil as groundwater, or runs off into lakes, streams, and oceans.

_____ Water vapor condenses into clouds.

_____ Evaporation transfers water from oceans, lakes, and streams to the atmosphere, in the form of into water vapor.

_____ Clouds release water back to the land through precipitation in the form of rain, snow, and hail.

14. Number these events to reflect how carbon moves through the environment, beginning with carbon in the atmosphere.

_____ Plants absorb carbon dioxide and break it down into carbon and oxygen during photosynthesis. This carbon is used to form carbohydrates. Carbon in plants is released when plants are burned, eaten by animals, or decompose.

_____ Carbon is stored in the atmosphere as carbon dioxide.

_____ Decomposing plants and animals release carbon into the soil or may be buried and become coal or oil.

_____ Animals get carbon from the plants and animals they eat. Animals release carbon by breathing, decomposing, or being eaten.

15. Number these events to reflect how nitrogen moves through the environment. Start with nitrogen in the atmosphere.

_____ Ammonification: Decomposers break down dead animals and plants, returning nitrogen to the soil by changing the nitrogen in them from ammonia to ammonium.

_____ Ammonification: Nitrogen-fixing bacteria in the soil convert nitrogen gas into ammonium.

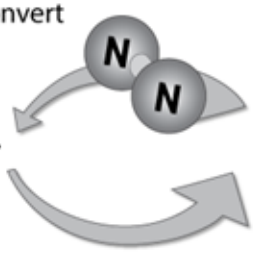
_____ Nitrogen is stored in the atmosphere as nitrogen gas.

_____ Assimilation: Plants absorb nitrogen from the soil as either ammonium or nitrate. Animals absorb nitrogen by eating plants.

_____ Nitrogen fixation: Nitrogen-fixing bacteria in the roots of legume plants convert nitrogen gas into ammonium.

_____ Denitrification: Some nitrogen from the soil is returned to the air by denitrifying bacteria. These bacteria change nitrate back into nitrogen gas.

_____ Nitrification: In a two-step process, bacteria in the soil convert ammonium into nitrite, and then into nitrate.



Multiple Choice

16. You touch a warm plate and your finger gets warm. This is an example of _____ .

    a. radiation

    b. convection

    c. conduction

17. Besides sunlight and water, which of the following is required for photosynthesis?

    a. oxygen

    b. carbon dioxide

    c. nitrogen

18. The conversion of ice or snow into a gas is called _____ .

    a. evapotranspiration

    b. condensation

    c. sublimation

19. Which of the following would be considered an abiotic factor in an environment?

    a. temperature

    b. detritivore

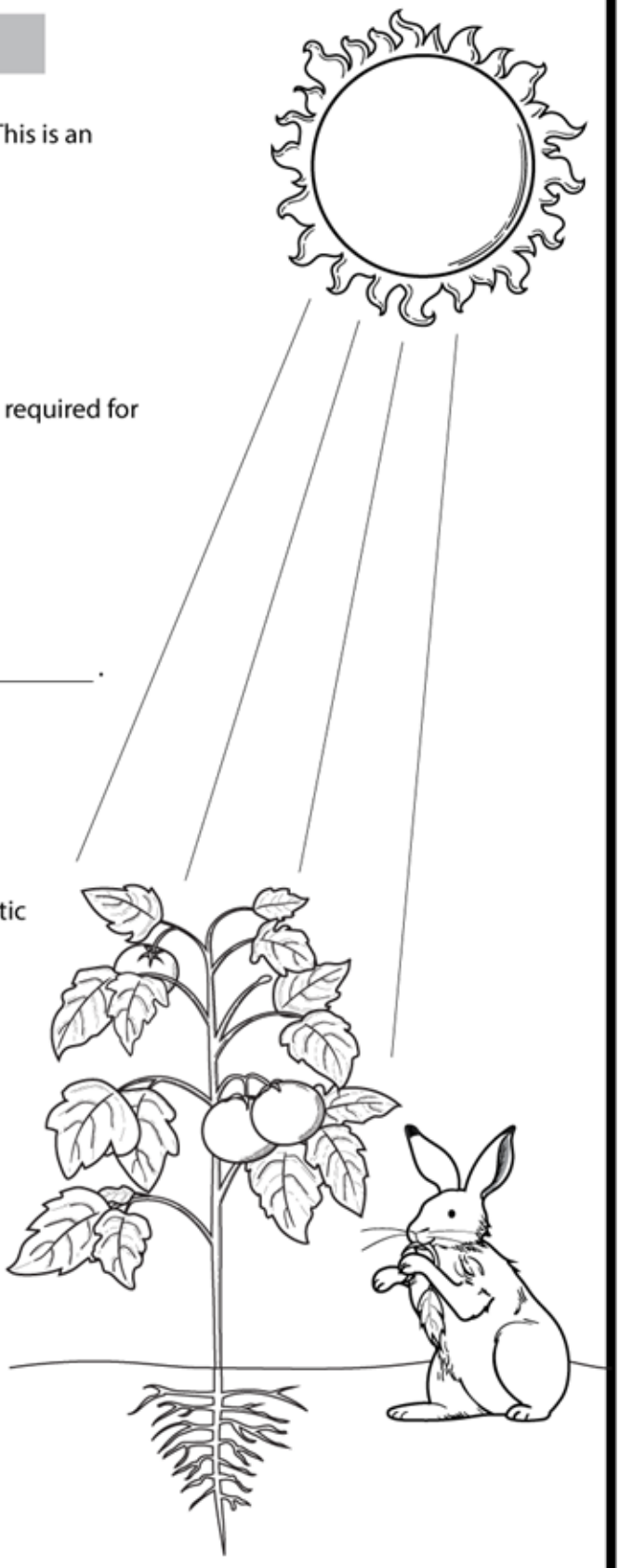
    c. heterotroph

20. A carbohydrate is made up of which elements?

    a. carbon, hydrogen, and nitrogen

    b. hydrogen, carbon, and oxygen

    c. carbon, boron, and hydrogen



Lesson 11: The Nitrogen Cycle

Getting Started

? Big Ideas

- If nitrogen is cycled through the environment, why is it often necessary to supplement nitrogen with fertilizer?
- How does knowledge inform responsible practices?

🕮 Facts and Definitions

- **Soil fertility** is the abundance of nutrients in soil that is beneficial for the growth of producers.
- **Fertilizer** is a compound or substance that supplies nutrients to plants. It can improve or change soil fertility.
- An **equilibrium** refers to the condition of a system in which competing influences are balanced.
- **Leaching** is the loss of water-soluble plant nutrients from the soil, due to rain and irrigation.
- **Eutrophication** occurs when too many nutrients enter a body of water (often due to leaching and fertilizer runoff), aquatic plants grow too much, and plant overgrowth uses up the available oxygen in the water, causing fish to die.

⦿ Skills

- Evaluate designed systems for their ability to enable growth of certain plants and animals. (S)
- Identify nutrients needed for plant growth. (S)

Introducing the Lesson

This unit has focused on the interconnectivity of cycles with energy and matter and the ecosystem. A second connection is the necessity of the cycles for life. In this lesson, your child will be asked to make a connection between the nitrogen cycle and the real-life practice of supplementing the nitrogen cycle with fertilizer in the context of lawn care.

Reading and Questions (Answers)

1. Why is fertilizer considered necessary?
   - Fertilizer aids natural cycles by putting more nitrogen and other needed compounds into the soil. Fertilizer increases the amount of a needed substance, which encourages more plant growth and production.
2. Is it possible to have too much nitrogen in an ecosystem? What happens?
   - When there is more nitrogen in an ecosystem than the plants can use, some of it is released back into the atmosphere where it contributes to global warming. Some of it also washes out of the soil and into rivers, lakes, and oceans. Too much nitrogen in an aquatic ecosystem causes algae to overgrow, which uses up the oxygen supply in the water and causes fish to die. This process is called eutrophication.
3. How does eutrophication demonstrate an aquatic ecosystem trying to restore equilibrium (balance)?
   - During eutrophication, plants and animals are competing for oxygen. In this case, plants win and the fish die out. As a result of this death, the ecosystem is in essence beginning to restore equilibrium — balance between the nutrients needed and the number of organisms the system can support.

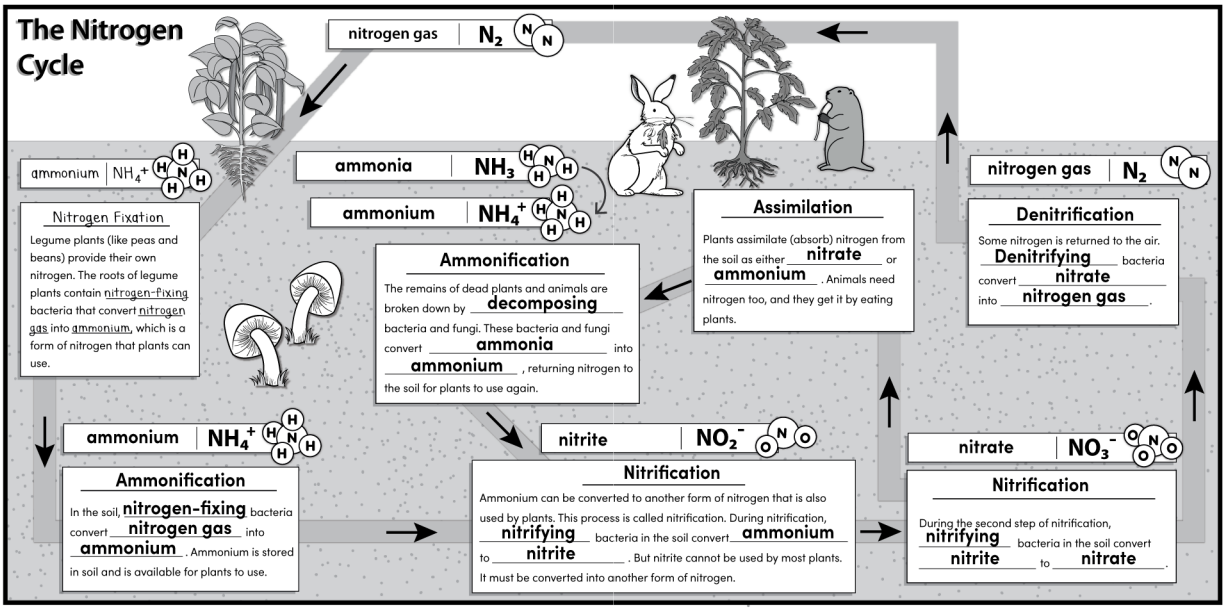
Activities

Activity 1: The Nitrogen Cycle

Your child will explore the nitrogen cycle in more depth using the web link. She will then follow the journey of a nitrogen atom by filling in the blanks on the activity page.

Answer Key:

Check your child's answers using the following key. She should also have colored the nitrogen (N) atoms blue, the oxygen (O) atoms pink, and the hydrogen (H) atoms green.



Activity 2: Plant Food

Your child will research fertilizers and explore how plants use nitrogen, phosphorus, and potassium. If she would like to understand eutrophication better, there are a number of good videos and websites that explain the process. You may wish to extend this activity by discussing these questions with your child: What factors could cause other Earth cycles to lose equilibrium? How might a loss of equilibrium in other cycles affect humans or other living organisms?

Answer Key:

Plant Diagram

Nitrogen encourages leaf growth, makes plants green, and is used by plants to make protein.
Phosphorus helps plants grow roots and produce fruit and seeds. It is also involved in photosynthesis.
Potassium supports plant stems and helps plants fight disease, cold temperatures, and dry weather.

Questions

1. How many pounds of each nutrient is in a 10-pound bag of 10-2-5 fertilizer? (Each number represents a percent of the total weight. A 10-2-5 fertilizer contains 10% nitrogen, 2% phosphorus, and 5% potassium.)
   Nitrogen: 10 pounds × 0.1 = 1 pound
   Phosphorus: 10 pounds × 0.02 = 0.2 pounds
   Potassium: 10 pounds × 0.05 = 0.5 pounds
2. Which of these nutrient ratios would be a good choice? (12-3-6)
3. Garden fertilizers often contain less nitrogen, more phosphorus, and more potassium than lawn fertilizers. Why do you think this is? (In a garden, you would want plants to grow more fruit rather than many leaves. Because nitrogen encourages leaf growth, and phosphorus and potassium encourage healthy plants with lots of fruit, garden fertilizers usually contain less nitrogen but more phosphorus and potassium.)

4. Which type of fertilizer would you recommend someone use for their lawn? Why?
   Organic or inorganic (chemical): (Answers will vary. Check that your child's reasoning is logical and supported by her research.)
   Quick release or slow release: (Answers will vary. Check that your child's reasoning is logical and supported by her research.)
5. Would you recommend getting a soil test before purchasing fertilizer? Why or why not? (Answers will vary. Check that your child's reasoning is logical and supported by her research. A soil test is useful for diagnosing nutrient deficiencies in lawns that do not look healthy. It is also useful to determine whether fertilizer is necessary at all, which prevents over-fertilization and subsequent damage to lawns and the environment.)
6. Besides using store-bought fertilizer, what is a more natural way to provide nitrogen to a lawn? (Nitrogen is released when plants and other organisms are decomposed. One option is to leave grass clippings on the lawn to decompose.)

Wrapping Up

Things to Review

- High levels of production cause strains on the natural cycles.
- Fertilization supplements natural cycles by adding necessary nutrients to the soil.
- Over-fertilization pollutes drinking water and causes eutrophication.

Final Project: A Sustainable Farm (3 Days)

Getting Started

? Big Ideas

- How can Earth cycles be used to ensure the survival of artificial ecosystems such as farms and gardens?
- How does knowledge inform responsible practices?

Facts and Definitions

- Sustainable farming methods allow a farm to work in harmony with the carbon, water, and nitrogen cycles.

Skills

- Apply water and nutrient cycles to an artificial ecosystem. (S)
- Research, evaluate, and apply agricultural techniques that improve soil health and crop yields. (S)
- Communicate scientific information in a clear, concise manner. (S)

Introducing the Lesson

In this final lesson, your child will study for and take a test to demonstrate what he has learned. His final project will be to plan a small farm. The objective of this project is to give him the opportunity to synthesize and use his knowledge of the carbon, water, and nitrogen cycles, while encouraging him to investigate and apply sustainable farming techniques.

As he does his research, he may come across both "sustainable farming" and "regenerative farming." The difference between the two is subtle in that regenerative farming seeks to make the soil and local ecosystem even better than it currently is, while sustainable farming seeks to maintain a sustainable farm that can produce healthy crops year after year. In reality, the techniques for both are extremely similar. For the purposes of this project, your child can consider the terms to be interchangeable.

Activities

Activity 1: Study for the Unit Test

Encourage your child to take as much time as needed to prepare for tomorrow's test. He may wish to have someone help him by quizzing him on key terms and concepts, and the steps for the carbon, water, and nitrogen cycles.

Activity 2: Plan a Sustainable Farm

In this activity, your child will research two or more farming techniques to apply on his farm. He may find some of the more scientific or technical search results difficult to understand. Be available to help him find solid, useful information that he can easily grasp, if he needs it. He can also use books from the library (books on gardening, composting, and forest gardens are especially easy to find). His research should tell him more about the technique as well as how to implement it with specific crops or animals.

Note: This project is intentionally open-ended in order to give your child freedom to research and design a farm he is enthusiastic about. While this project does not have a rubric, encourage your child to give his best effort.

Day 2

Activity 3: Take the Unit Test

Your child will take the test for this unit. Check his answers. If he scores less than 80 percent, have him study again and retake it.

Answer Key:

Matching

1. F
2. I
3. C
4. G
5. A
6. K
7. E
8. B
9. H
10. J
11. D

Ordering

12. Number these events to reflect how energy and matter move through the environment. Start with the Sun.

1. Electromagnetic energy radiates from the Sun and reaches the Earth.
2. Autotrophs use light energy from the Sun, water, and carbon dioxide to make food (carbohydrates) for themselves. Where light is not available, some autotrophs use chemicals. Cells use the energy stored in carbohydrates to survive.
3. Heterotrophs consume autotrophs, the products of autotrophs (like seeds and fruits), or other heterotrophs. Heterotrophs indirectly consume energy from the Sun by breaking down carbohydrates and other molecules from these organisms.
4. Decomposers eat heterotrophs and autotrophs when they die, breaking down the organic matter so that it can be reused. However, energy that has been absorbed and transferred through autotrophs, heterotrophs, and decomposers is either used by the organisms or released back into the environment as heat.

13. Number these events to reflect how water moves through the environment, starting with evaporation.

1. Evaporation transfers water from oceans, lakes, and streams to the atmosphere, in the form of into water vapor.
2. Water vapor condenses into clouds.
3. Clouds release water back to the land through precipitation in the form of rain, snow, and hail.
4. Precipitation is absorbed and stored in the soil as groundwater, or runs off into lakes, streams, and oceans.

14. Number these events to reflect how carbon moves through the environment, beginning with carbon in the atmosphere.

1. Carbon is stored in the atmosphere as carbon dioxide.
2. Plants absorb carbon dioxide and break it down into carbon and oxygen during photosynthesis. This carbon is used to form carbohydrates. Carbon in plants is released when plants are burned, eaten by animals, or decompose.
3. Animals get carbon from the plants and animals they eat. Animals release carbon by breathing, decomposing, or being eaten.

4. Decomposing plants and animals release carbon into the soil or may be buried and become coal or oil.

15. Number these events to reflect how nitrogen moves through the environment. Start with nitrogen in the atmosphere.

NOTE: Steps 2 and 3 can be in either order. Denitrification (Step 7) can also be placed after nitrification (Step 4).

1. Nitrogen is stored in the atmosphere as nitrogen gas.
2. Nitrogen fixation: Nitrogen-fixing bacteria in the roots of legume plants convert nitrogen gas into ammonium.
3. Ammonification: Nitrogen-fixing bacteria in the soil convert nitrogen gas into ammonium.
4. Nitrification: In a two-step process, bacteria in the soil convert ammonium into nitrite, and then into nitrate.
5. Assimilation: Plants absorb nitrogen from the soil as either ammonium or nitrate. Animals absorb nitrogen by eating plants.
6. Ammonification: Decomposers break down dead animals and plants, returning nitrogen to the soil by changing the nitrogen in them from ammonia to ammonium.
7. Denitrification: Some nitrogen from the soil is returned to the air by denitrifying bacteria. These bacteria change nitrate back into nitrogen gas.

Multiple Choice

16. c
17. b
18. c
19. a
20. b

Activity 4: Choose Your Crops

For this part your child will choose the plants and animals he will include on his farm. He should take into consideration the sustainable farming techniques he would like to apply, and choose plants and animals that are appropriate for those techniques. Although it is not required, encourage him to consider pesticide and fertilizer use, equipment costs, labor needs, and/or the effects a crop may have on climate or the local environment. He will then make a rough sketch of his farm.

Activity 5: Create a Sustainable Farm Display

Your child can choose how to make his display. Encourage him to be creative and thorough. Help him as needed with research and providing materials.

Day 3

Activity 6: Finish Your Sustainable Farm Display

Explore your child's sustainable farm display. Be sure to compliment him on any aspect he did particularly well. If he enjoyed this project, you may wish to encourage him to explore careers in agriculture. The agricultural field encompasses far more than growing crops. Careers include soil science, engineering, finance, management, communications or journalism, agricultural research, and many more.

Wrapping Up

Questions to Discuss

- What did you enjoy most about the final project? What was the most challenging part?
- How do you interact with Earth's cycles on a daily basis?
- What changes could you or your family make to be better stewards of Earth's cycles?