LESSON 2

Plant Bodies as Systems

Dragon blood trees have a wide, dense canopy of leaves that protects the soil below from the hot sun.

By the end of this lesson . . .

you will be able to evaluate how the survival needs of plants are met by systems working together.

Go online to view the digital version of the Hands-On Lab for this lesson and to download additional lab resources.

CAN YOU EXPLAIN IT?

How can the onyanga thrive in the harsh conditions of the Namib Desert?

The onyanga grows in the Namib desert, where there is little rain but regular, dense fog develops at night.

For many hundreds of years—and possibly even thousands of years—this plant has been growing where not much else can grow. It grows only two leaves that become ragged and torn over time, a stem, and roots. It may not look like much, but it can go without rain for up to 5 years. The largest onyanga plants are estimated to be nearly 2,500 years old!

1. Why do you think this plant is able to grow in an environment where few other plants can survive?

EVIDENCE NOTEBOOK As you explore the lesson, gather evidence to help you explain how the onyanga's body systems help it survive.

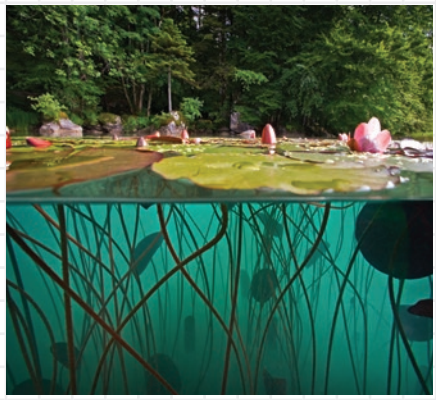
Exploring Plant Body Systems

Plants live on every continent on Earth. They live in places such as lush forests and expansive grasslands. They also live in places you might not expect, such as dry deserts and frozen tundra. They range in size from the tallest giant sequoia trees, reaching more than 80 meters, to the smallest flowering plant, which can fit on the tip of your finger.

All plants are multicellular. They are also eukaryotes—their cells contain membrane-bound organelles, including a nucleus that contains the cell's genetic information. All plants have cell walls and large vacuoles. All plants convert the energy from sunlight to food energy by a process called *photosynthesis*.

This maple tree has a central stem, called a *trunk*, that connects the roots to the branches of the tree.

The root system of the saguaro cactus is shallow, but it reaches out as far as the plant is tall.



The water lily's broad, flat leaves float on the water to maximize the amount of sunlight they can capture.

2. Discuss With a partner, gather information from the text and the photos to compare the plants shown above. Record your observations in the table.

Similarities	Differences

The Plant Body System

Plants can be divided into two major groups based on the structure and function of their body systems. Most of the land plants on Earth today have a vascular system. A *vascular system* transports materials and provides support to the plant body. Plants that have a vascular system are called *vascular plants*. Plants that do not have a vascular system are called *nonvascular plants*.

Plant Cells

Like all living things, plants are made of cells. Plant cells have rigid cell walls, which help to provide structure and support for the plant.

Plant Tissues

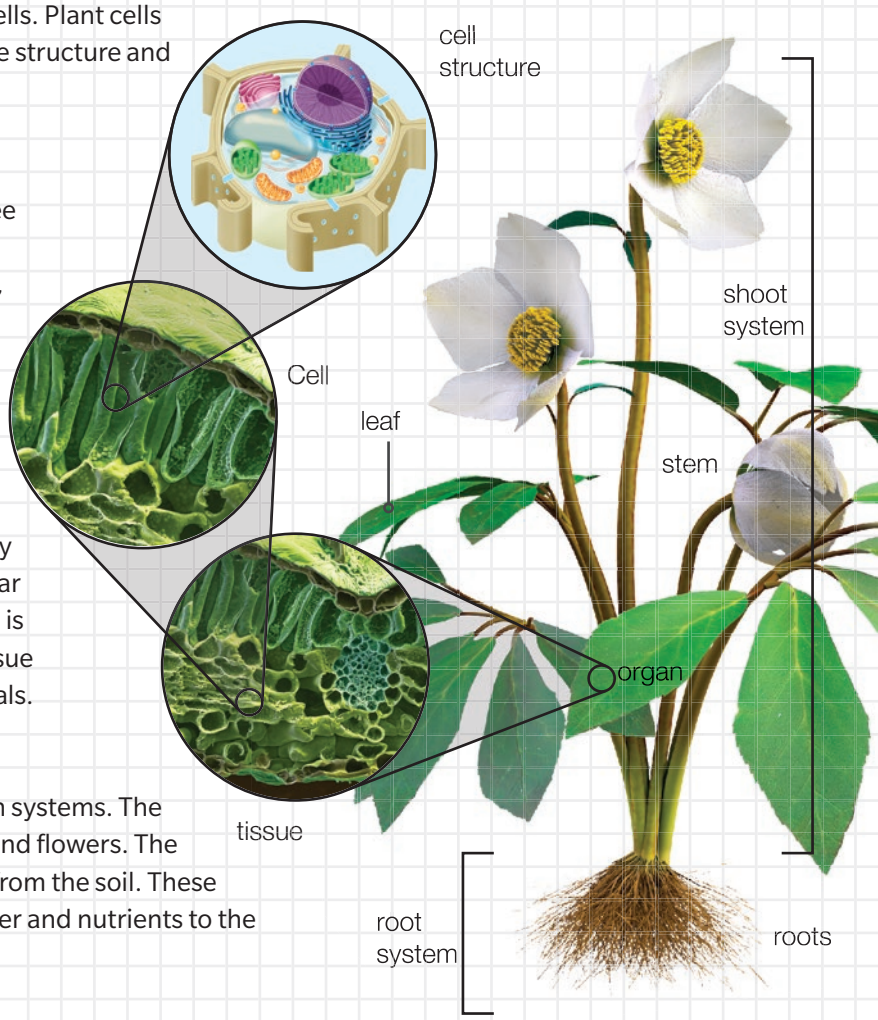
The cells in a plant are organized into three tissue types. *Dermal tissue* protects the plant, *vascular tissue* transports materials, and *ground tissue* provides support and storage.

Plant Organs

Leaves, stems, roots, and flowers are all plant organs made up of the three tissue types. For example, the stem is covered by dermal tissue. Inside the stem, the vascular tissue that transports water and nutrients is surrounded by ground tissue. Ground tissue gives the stem support and stores materials.

Plant Organ Systems

Plant organs are organized into two organ systems. The *shoot system* includes the leaves, stems, and flowers. The *root system* takes up water and nutrients from the soil. These two systems work together to deliver water and nutrients to the entire plant.



3. Use this plant diagram as evidence to support the claim that organ systems work together to allow organisms to survive and grow.

EVIDENCE NOTEBOOK

4. The onyanga has a wide, shallow root system. How might this type of root system help the onyanga collect nightly fog? Record your evidence.

Analyze a Plant Body System

Sundews live in habitats where sunlight and water are plentiful, but the soil has few nutrients. Like most plants, sundews make their own food using energy from sunlight. Unlike most plants, sundews also capture and digest insects. Sundew leaves are covered with tentacle-like structures that contain a sweet, sticky substance. Insects attracted to the sundew for a tasty meal get trapped in the leaf and are digested by the plant.

When an insect lands on a sundew, it gets stuck on the sticky leaf. The leaf curls around the trapped insect, which is digested by the plant.

Explore ONLINE!

5. Why do you think sundews need to capture insects?

- **A.** The sundew is unable to make enough food.
- **B.** The insects provide water to the plant.
- **C.** The sundew is protecting itself from insects.
- **D.** The insects provide nutrients that are missing from the soil.

6. Sundews have weakly developed roots. Why do you think sundews do not need strong roots?

7. How does the structure of the sundew leaf relate to its function?

Describing How Plant Systems Process Nutrients

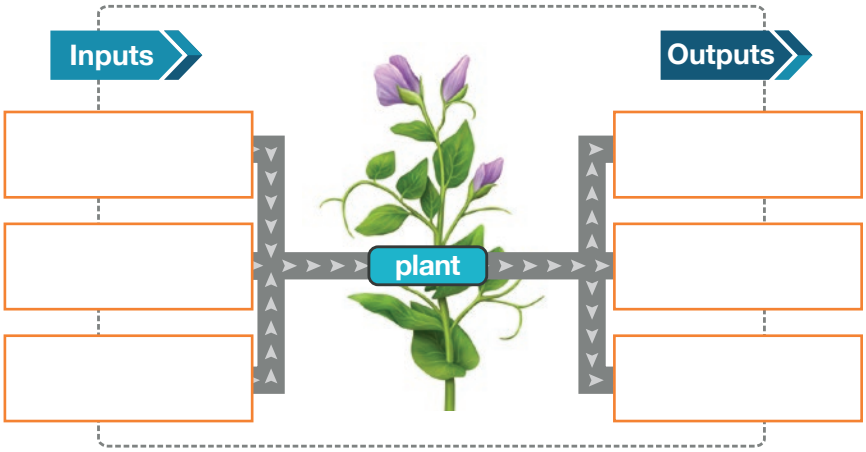
Plants bodies are systems that perform all the processes needed for a plant to live. Plants need sunlight, water, and carbon dioxide to make and transport the food they use as fuel. They also need oxygen to convert the food to energy that is used by all parts of the plant. Nutrients from the soil, such as nitrogen and phosphorus, are used for cellular processes and growth. All of these processes produce unwanted products, so plants also need to get rid of wastes to stay healthy.

Making Food

Like you, plants need food that cells can use for energy. But unlike you, plants do not get their food by eating. Instead, plants make their own food by the process of photosynthesis. *Photosynthesis* is the process that uses energy from sunlight to convert water molecules and carbon dioxide into sugars and oxygen. A **leaf** is the plant organ that is the main site of photosynthesis. The sugars produced in leaf cells are transported from the leaves to all parts of the plant's body.

Inputs and Outputs of Photosynthesis

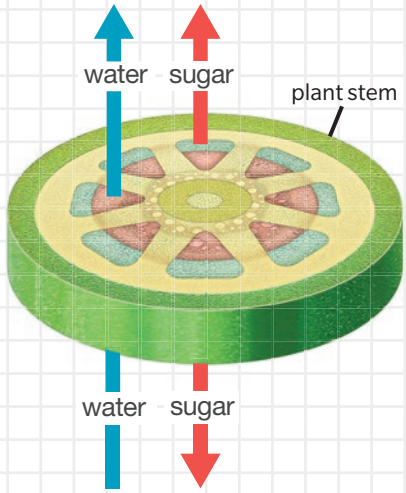
8. Complete the diagram by labeling the inputs and outputs of the process of photosynthesis. Use evidence from the text.



9. Engineer It Solar cells are devices that collect energy from sunlight and convert it into electricity. What plant structure might engineers look at when they are designing the way that solar cells are arranged? Explain your reasoning.

Moving Materials

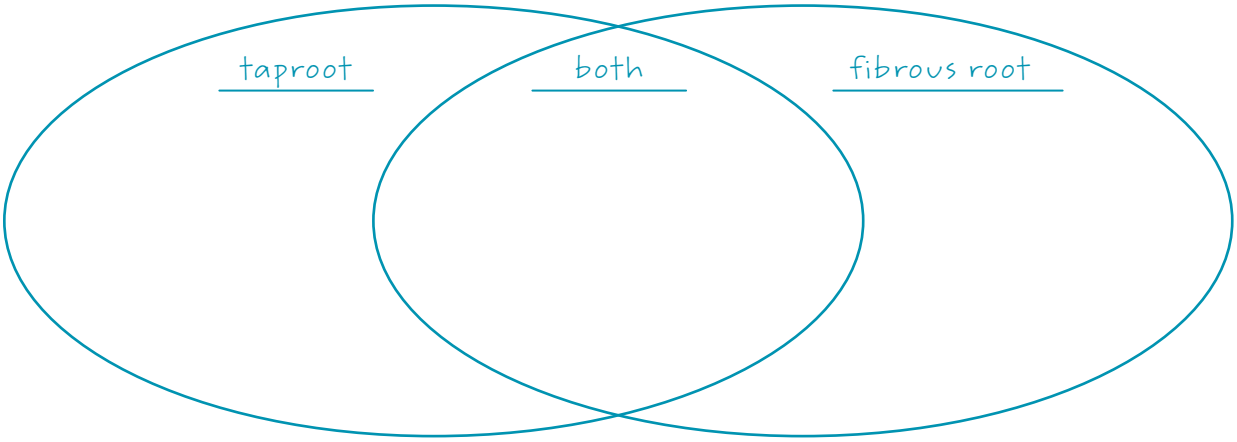
Materials move through a plant through two kinds of vascular tissue—xylem and phloem. Water and dissolved nutrients enter the plant through the **roots**, organs that absorb water and dissolved nutrients from soil. Roots also anchor the plant in the ground. Roots connect to **stems**, organs that transport nutrients to all parts of the plant body and provide support to the plant. Water moves from the roots to the stems through tube-shaped cells in the xylem tissue. Sugars made during photosynthesis move throughout the plant in the phloem.



Compare Root Systems

10. Using the word bank, complete the Venn diagram by entering the functions you think best describe the root systems.

• absorbs nutrients	• absorbs water
• stores nutrients	• anchors plant
• drought tolerant	• protects soil



Some plants have a root system called a taproot. As you can see in the photo, these plants have one large main root structure with many smaller branch roots. Taproots can grow deep into the soil.

Other plants have a fibrous root system, in which many branching roots grow close to the soil surface. Fibrous roots can spread wide and form mats that anchor the plant very firmly in the soil.

Hands-On Lab

Observe Transport

You will compare and contrast the movement of water through the stems of two different types of plants.

MATERIALS

- asparagus spears
- broccoli stems
- clear plastic cups, 16 oz (2)
- graduated cylinder
- knife
- red food coloring
- stir stick

Procedure

STEP 1 Fill two 16 oz cups with 100 mL of water each. Add 10–15 drops of red food coloring and mix thoroughly.

STEP 2 Use the knife to cut 8 cm sections of the broccoli stem and the asparagus spears. Be sure to cut the stems horizontally.

STEP 3 Place one or two pieces of broccoli stem in one cup and one or two pieces of asparagus spears in the other cup. Be sure the stems stand upright in the water and will not fall over.

STEP 4 Allow the stems to sit in the water for 24 hours. Cut your stems at 1–2 cm intervals to see how far the water traveled up the stems.

STEP 5 Record your observations in the data table below.

Asparagus	Broccoli

Analysis

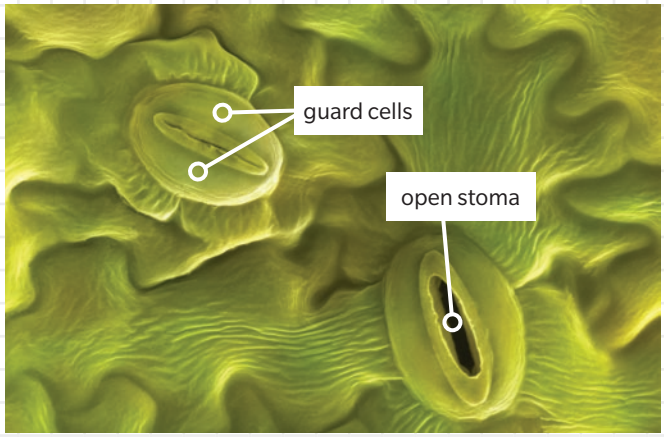
STEP 6 How do your observations from this activity provide evidence for the function of a plant's vascular system?

STEP 7 Through which vascular tissue did the water move in the broccoli and asparagus stems?

Disposing of Wastes

Plants produce waste as a result of cell processes, such as photosynthesis. Water, carbon dioxide, and oxygen enter and exit a plant through tiny openings in the leaf surface, called stomata (*sing.* stoma).

Plants also need to get rid of unwanted substances that may enter their systems through water. Some plants store wastes in living cells, such as leaves. These unwanted materials are removed when the leaves fall from the plant.



The size, shape, and placement of stomata allow water and gases to efficiently move in and out of the plant.

11. A plant system must balance its need for water with its need for carbon dioxide and oxygen. If too much water is lost, the stomata will close. How does this affect a plant's ability to regulate levels of carbon dioxide and oxygen?

12. Discuss What would likely occur if most of a plant's stomata became blocked? Explain your reasoning.

Language SmArts

Use Observations to Develop an Argument

13. This plant has shallow roots, short stems, and leaves that are covered in fuzzy hairs. In what type of environmental conditions might this plant live? Use your observations as evidence to support your argument.

Describing How Plant Systems Respond to the Environment

Unlike many animals, plants cannot move to a new place when their environment changes. Plant bodies respond to a variety of environmental factors. Many of these responses happen very slowly. Other responses are surprisingly fast! The Venus flytrap will respond to the touch of an insect in a few seconds by snapping its leaf shut. Two factors that plants respond to are light and water.

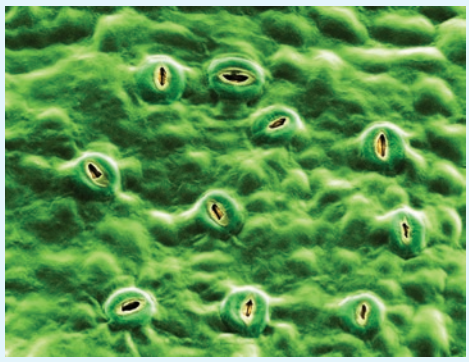
14. Why do you think it is important for plants to be able to regulate the level of water in their bodies?

Regulating Water

Plants regulate the water in their bodies in response to environmental conditions. Plants regulate water in their bodies mostly by opening and closing their stomata. Two guard cells control the opening and closing of each stoma. Stomata open to allow air to move in and out. They close to prevent water loss. Some plant leaves also have a waxy coating that helps prevent water loss. Plants may also store water in their stems, leaves, or roots.

Do the Math

Calculate Stomata Percentage



The percentage of stomata on a leaf surface can be calculated using the equation:

$$\text{Stomatal percentage} = \frac{S}{S+E} \times 100$$

where S = the number of stomata and E = the number of epidermis cells, which form the outer layer of a leaf.

Look at the photo of the leaf.

15. Count and write the number of open stomata that you can see. _____

16. If the number of epidermis cells in this area is 150, what is the percentage of stomata in this area of the leaf?

17. Stomata percentage on a particular plant can change depending on environmental conditions. What environmental factors might influence the percentage of stomata? Explain your thinking.

EVIDENCE NOTEBOOK

18. The onyanga opens its stomata only at night for necessary gas exchange. How might this adaptation help the plant survive in its environment? Record your evidence.

Responding to Light and Gravity

Have you ever noticed your houseplant growing toward the window? One way that plants respond to their environment is by growing toward a light source. This process is called *phototropism*. Chemical messengers build up on the shaded side of the plant's stem. These messengers cause the cells to grow longer. As the cells on the shaded side grow longer, they cause the stem to bend toward the light source.

19. What advantage do you think growing toward a light source gives a plant?

A change in the direction of plant growth in response to gravity is called *gravitropism* or *geotropism*. Most stems grow upward, away from the pull of Earth's gravity. Most roots grow downward, toward the pull of gravity.

Construct an Explanation

20. Water pressure in stems and leaves helps to keep a plant rigid. A plant wilts when there is a lack of water. How do interactions at the cell and tissue levels cause a plant to wilt? Explain your reasoning.

Continue Your Exploration

Name: **Date:**

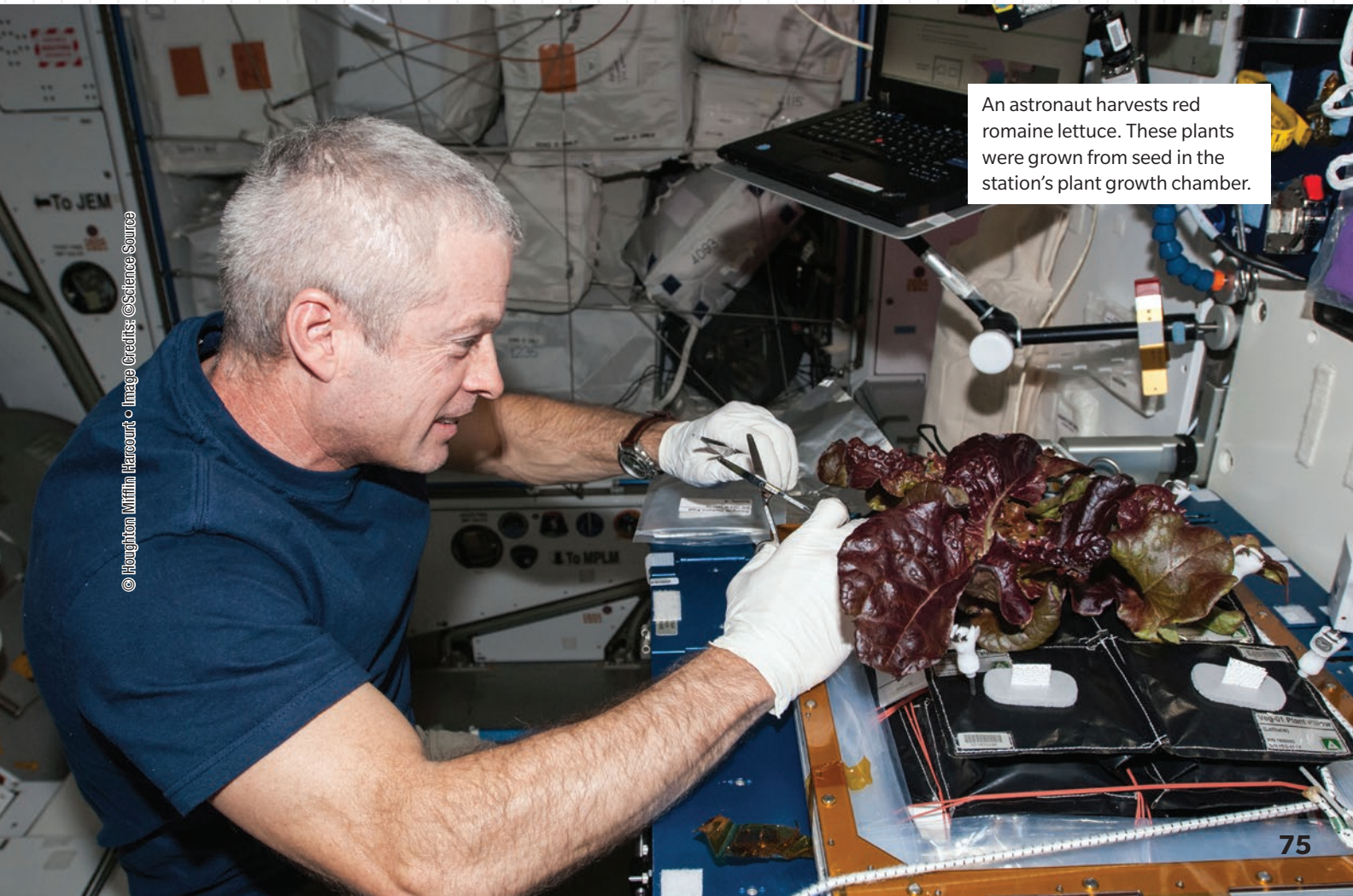
Check out the path below or go online to choose one of the other paths shown.

Growing Plants in Space

- **Hands-On Labs**
- **Feeding the World Using Less Water**
- **Propose Your Own Path**

Go online to choose one of these other paths.

The International Space Station is a research laboratory that travels at a speed of 8 km per second and orbits Earth every 90 minutes. Solar panels provide power to the station, and life support systems supply oxygen and remove unwanted gases from the enclosed space. The water supply is supplemented by capturing and recycling the water vapors that enter the cabin when the crew members exhale and sweat! The crew members are researching ways to grow food on the space station in the hopes that they will be able to have fresh food available for extended periods of time in space.



An astronaut harvests red romaine lettuce. These plants were grown from seed in the station's plant growth chamber.

Continue Your Exploration

1. One way that plants respond to their environment is by growing in response to gravity, or *gravitropism*. Roots grow toward the direction of the gravitational pull (downwards). Stems grow opposite to the gravitational pull (upwards). The force of gravity is very weak on the space station, a condition referred to as microgravity. How might microgravity affect the growth of plants on the space station? Select all that apply.

- **A.** The length and shape of the roots and stems of the plants grown in space might be different than the same plants grown on Earth.
- **B.** The plant may not be able to absorb and transport water and nutrients in microgravity.
- **C.** The plant would not be able to respond to light in microgravity.

2. One of the biggest challenges of long-term space travel is having a sufficient supply of fresh water. Water must be recycled and used sparingly to ensure that the crew will have enough water to drink and to bathe. What types of plants from Earth would be good candidates for food plants for the crew of the space station? Select all that apply.

- **A.** plants from dense areas of vegetation that are adapted to growing in small spaces
- **B.** plants from dry areas that are adapted to drought conditions
- **C.** plants from shady areas that are adapted to very little light

3. Do you think the plants on the space station are able to conduct photosynthesis? Explain why or why not.

4. Collaborate Research plant growth in space. You may also find out more about the space garden on the International Space Station. Describe the evidence that researchers have gathered or are gathering to help answer their questions. Collaborate to define a question that you would like to answer about plant growth in space. Describe the evidence you would need to collect to answer your question.

Can You Explain It?

Name: **Date:**

How can the onyanga thrive in the harsh conditions of the Namib Desert?

EVIDENCE NOTEBOOK

Refer to the notes in your Evidence Notebook to help you construct an explanation of how the onyanga can survive in the Namib Desert.

1. State your claim. Make sure your claim fully explains the organs and organ systems involved in the functions that allow the onyanga to survive.

2. Summarize the evidence you have gathered to support your claim and explain your reasoning.

Checkpoints

Answer the following questions to check your understanding of the lesson.

Use the photo to answer Questions 3 and 4.

3. Prickly pear cacti live in hot, dry habitats. The spines are modified leaves that do not have stomata. The green stems of the cactus store water and are covered in stomata. The site of photosynthesis in the prickly pear is likely to be the spines / stems.

4. Which statement best describes the relationship between structure and function in the prickly pear cactus? Select all that apply.

A. The stems are wide to maximize the capture of sunlight.

B. The spines are narrow because they do not have stomata.

C. The spines protect the stem from animals that try to eat the cactus.

D. The stems are wide to maximize the amount of water that can be stored.

Use the photo to answer Questions 5 and 6.

This red mangrove tree has specialized roots, called pop roots, that extend above the ground.

5. The specialized roots of the mangrove tree help the tree to anchor / float in the sandy soil. The aboveground portions deliver oxygen / sunlight to the roots that are under the water.

6. Mangrove trees live in saline conditions that would kill most other types of plants. How do you think the mangrove tree is able to tolerate this environment?

A. The mangrove tree needs more salt than other plants to live.

B. The mangrove tree disposes of salt through its leaves.

C. Animals that live on the tree eat the salt from the tree.

D. The mangrove tree does not grow as well as trees that do not live in salty conditions.

Interactive Review

Complete this section to review the main concepts of the lesson.

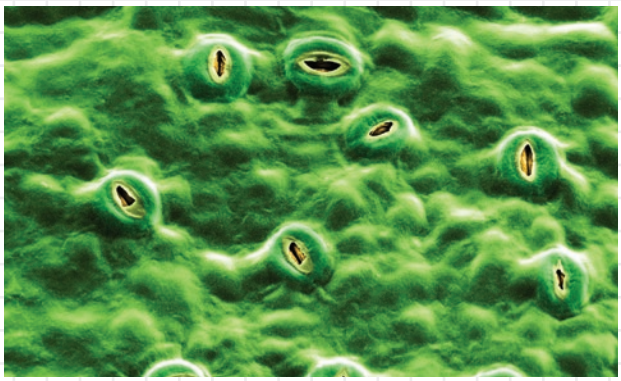
Plant bodies are made up of cells that form tissues, organs, and organ systems.

A. Describe why the interaction of the different levels of organization in the plant body are needed for the plant body system to function.

Plant bodies are systems that perform all the functions needed by the plant to live.

B. Draw Make a diagram to explain how a plant's root system and shoot system work together to provide the plant with food, water, and soil nutrients.

Plant body systems respond to the environment.



C. Describe the cause-and-effect relationships between conditions in the environment, such as light, and a plant's response to light.