LESSON 1

Levels of Organization in Organisms

The hard shell of the thorn bug helps it blend in with the plant it lives on, and also provides a protective armor.

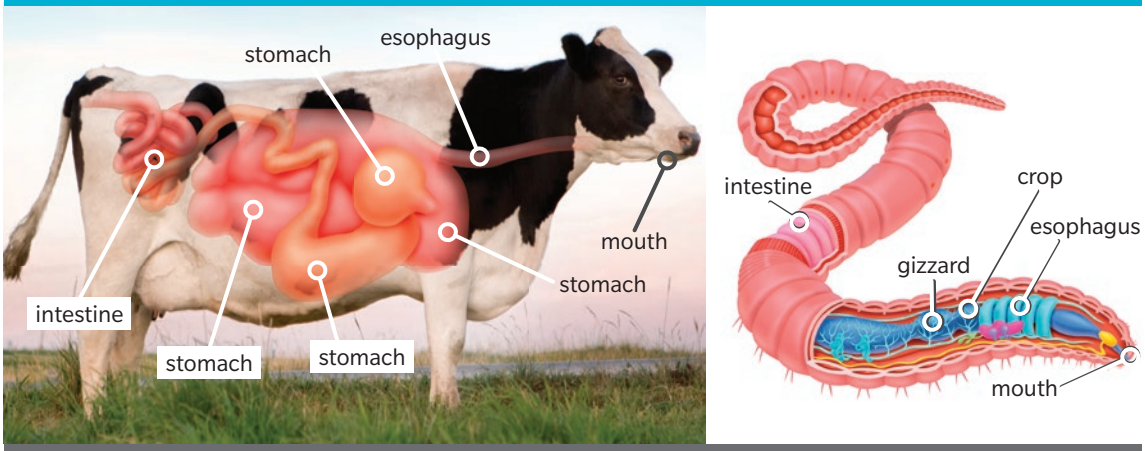
By the end of this lesson . . .

you will be able to relate structure to function at each level in an organism.

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 systems with such different structures perform the same function?



Cows are animals that eat grass, hay, and other hard-to-digest plants. Earthworms are animals that live in soil and eat decaying plant and animal matter.

1. The cow's digestive system and the worm's digestive system both break down food, but they do not look the same. Compare and contrast the two systems. What explanation can you suggest to explain the similarities and differences between the two digestive systems?

EVIDENCE NOTEBOOK As you explore the lesson, gather evidence to help you explain the structures of the two digestive systems.

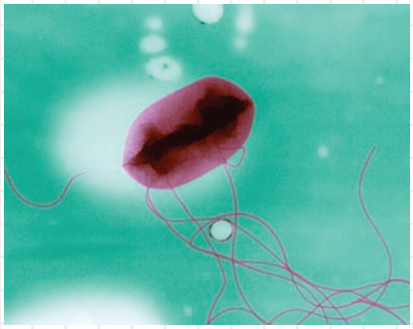
Exploring Levels of Organization in Organisms

Living Things Are Organized

Every living thing is a system that performs all the processes needed for survival. Some living things are made up of multiple subsystems. Other living things are a system of only a single cell.

Cells

An **organism** is a living thing made up of one or more cells that can perform all the processes needed for life. Organisms that are made up of a single cell are called *unicellular* organisms. Unicellular organisms have one level of organization. All the functions needed for life are performed by one cell. *Multicellular* organisms are made up of more than one cell. The cells that make up a multicellular organism are specialized and organized to perform specific functions. Multicellular organisms have more than one level of organization.



E. coli bacteria are unicellular. They have whip-like structures that help them move and attach to host cells.

Oak trees are multicellular. They have many leaves to capture sunlight and a specialized stem called a *trunk*.

The Eurasian water shrew is multicellular. It uses its sensitive whiskers to hunt under water.

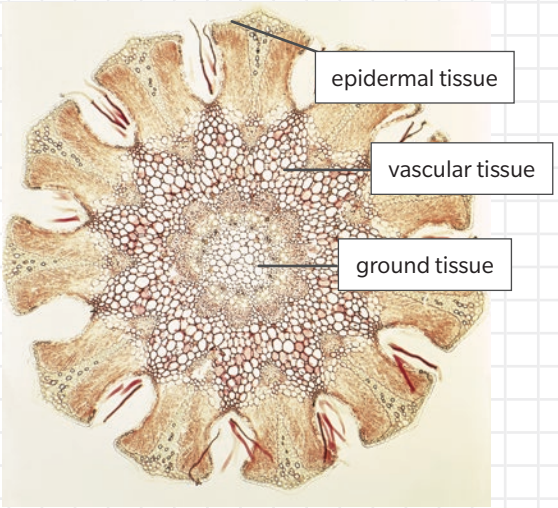
2. Discuss Multicellular organisms can be made up of billions of cells. How do you think having specialized cells is an advantage for a multicellular organism?

Tissues

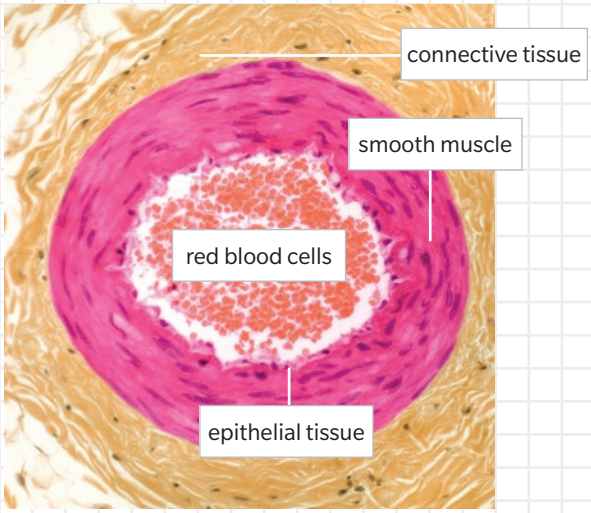
In organisms, such as plants and animals, specialized cells are grouped together in tissues. A **tissue** is a group of similar cells that are organized to perform a specific function. For example, certain specialized cells in the oak tree are small and hollow. These cells connect together to form a tissue, called *vascular tissue*, that transports water throughout the tree.

Organs

Different types of tissues that function together form an **organ**. For example, the stem of the oak tree is an organ that is made up of vascular tissue that transports water, ground tissue that provides support, and epidermal tissue that protects the outside of the stem. Blood vessels are organs in the shrew made up of epithelial tissue that controls the passage of blood cells, layers of smooth muscle tissue that control the diameter of the vessel, and a tough wall of connective tissue.



Stems are plant organs that transport materials and provide support for the plant.



Blood vessels transport blood and nutrients and remove wastes in the body.

3. Use the oak tree stem as evidence to support the claim that specialized tissues work together to form organs that perform necessary functions.

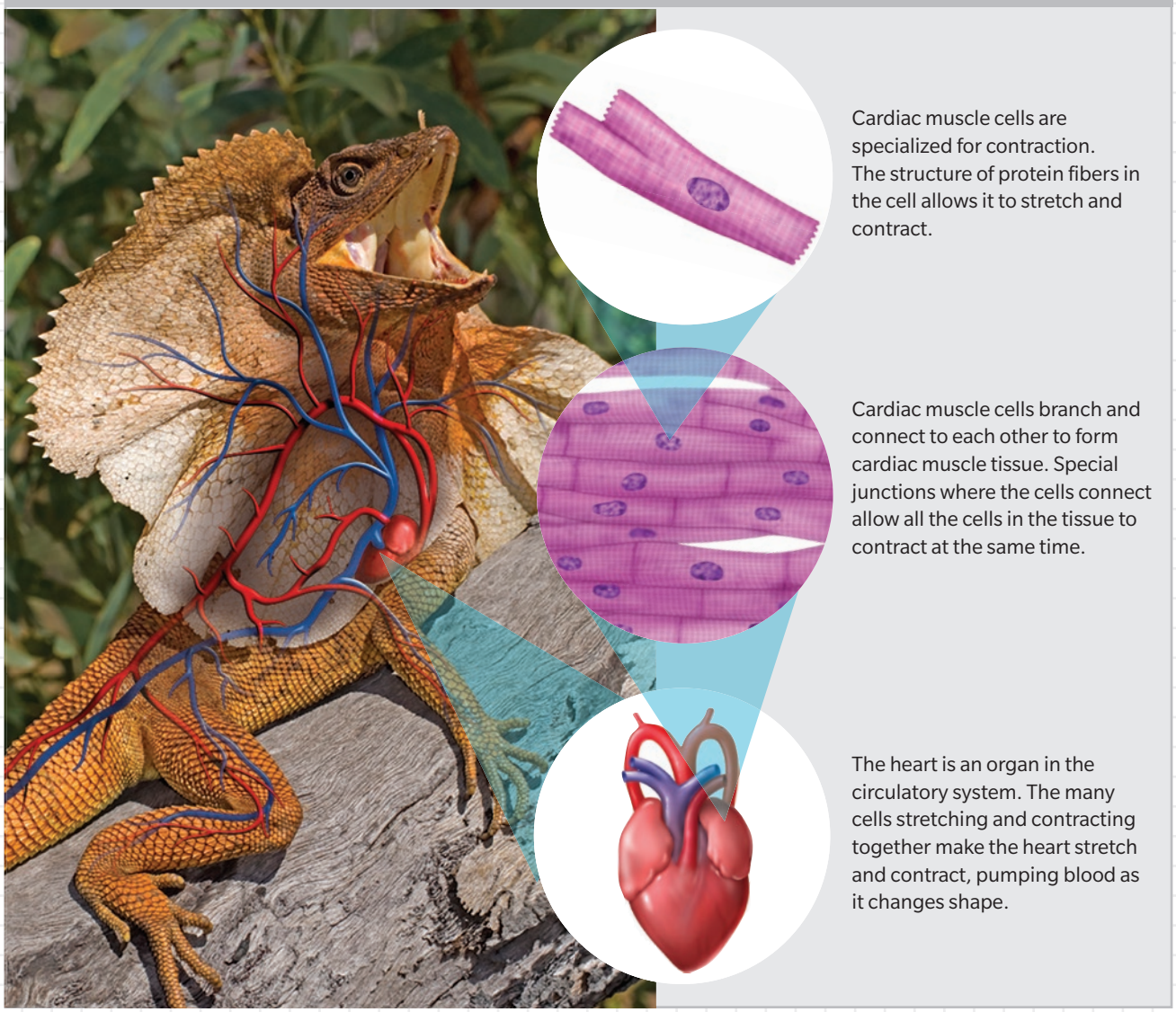
Organ Systems

An **organ system** is a group of organs that work together to perform body functions. The leaves, stems, and flowers are organs of the shoot system of the oak tree. In the shrew, a muscular heart and blood vessels are organs of the circulatory system that delivers blood to all the cells in the shrew's body. An organism can have many organ systems that work together to perform all the functions the organism needs to survive.

4. Draw a diagram that shows the relationship between cells, tissues, organs, and organ systems.

Analyze Levels of Organization in a Lizard

When this frilled lizard is threatened, its heart rate increases in preparation to fight or to run away. The lizard stands on its back legs, hisses, and expands the large skin flap that surrounds its neck.



Cardiac muscle cells are specialized for contraction. The structure of protein fibers in the cell allows it to stretch and contract.

Cardiac muscle cells branch and connect to each other to form cardiac muscle tissue. Special junctions where the cells connect allow all the cells in the tissue to contract at the same time.

The heart is an organ in the circulatory system. The many cells stretching and contracting together make the heart stretch and contract, pumping blood as it changes shape.

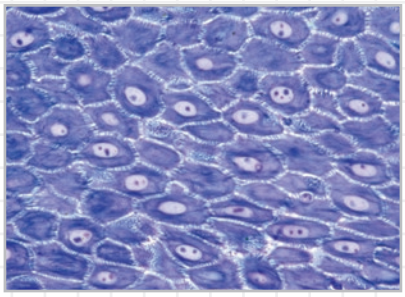
5. Is the frilled lizard unicellular or multicellular? Use evidence to explain your answer.

6. Use frilled lizard as evidence to support the claim that organs work together to form organ systems that perform necessary functions.

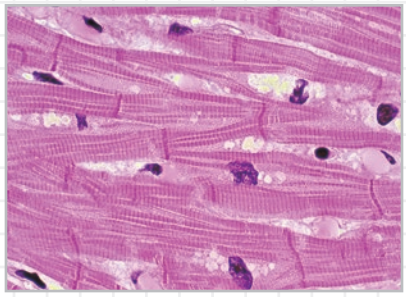
Hands-On Lab

Model Tissue Structure and Function

You will model two different tissue types and relate their structure to their function.



This tissue protects the skin from abrasion. It can be especially thick on the heels of your feet.



This tissue is located in the heart. It stretches and contracts to make the heart pump blood.

MATERIALS

- adhesive putty
- beads
- cardboard
- construction paper
- foam peanuts
- glue
- markers
- modeling clay
- pompoms
- rice
- rubber bands
- scissors
- sponges
- tape

Procedure and Analysis

STEP 1 Look at the tissues in the photos. Record your observations about the structure and shape of the cells.

STEP 2 Choose the materials that you think will best model the cells and how they are connected to form tissues. Construct a model of each of tissue.

STEP 3 Describe how your models represent groups of cells working together to form tissues.

STEP 4 Use your models to make a claim about how the role played by different types of tissues within an organ depend on the structure of its cells.

EVIDENCE NOTEBOOK

7. The gizzard in the earthworm contains small stones that help grind up bits of food. Why might the earthworm have a gizzard but the cow does not? Record your evidence.

Do the Math | Analyze Size and Scale in Organisms

Have you ever wondered how many cells are in your body? Biologists use a unit of measure called a *nanogram* (ng) to measure the mass of cells and other microscopic structures. There are 1 billion, or 10^9, nanograms in 1 gram.

This hedgehog is being weighed before his winter sleep.

8. If the average mass of a cell is 1 nanogram, approximately how many cells are in the body of a hedgehog that weighs 400 grams?

STEP 1 Convert 400 grams to nanograms.

$$400\ \text{g} \times \frac{10^9\ \text{ng}}{1\ \text{g}} = \underline{\qquad\qquad}\ \text{ng}$$

STEP 2 Use the ratio $\frac{1\ \text{cell}}{1\ \text{ng}}$ to find the number of cells in the body of the hedgehog.

$$\underline{\qquad\qquad}\ \text{ng} \times \frac{1\ \text{cell}}{1\ \text{ng}} = \underline{\qquad\qquad}\ \text{cells}$$

9. The pancreas is an organ that is part of the digestive system. The hedgehog's pancreas has a mass of 4 grams. What percent of the hedgehog's total mass is the mass of the pancreas?

STEP 1 Write the ratio of the mass of the pancreas to the total mass of the hedgehog.

$$\frac{4\ \text{g (pancreas)}}{400\ \text{g (total mass)}} = \underline{\qquad\qquad}$$

STEP 2 Multiply by 100 to convert to percent.

$$\underline{\qquad\qquad} \times 100 = \underline{\qquad\qquad}\ \%$$

Categorize a Level of Organization

10. Discuss Blood is made up of blood cells suspended in a liquid matrix called *plasma*. Blood contains red blood cells, white blood cells, and platelets. Blood provides all the cells in the body with oxygen, helps regulate body temperature, and helps the body fight infection. With a partner, discuss whether you think blood is a tissue, a fluid, or both. Support your argument with evidence.

Relating Structure to Function in Living Things

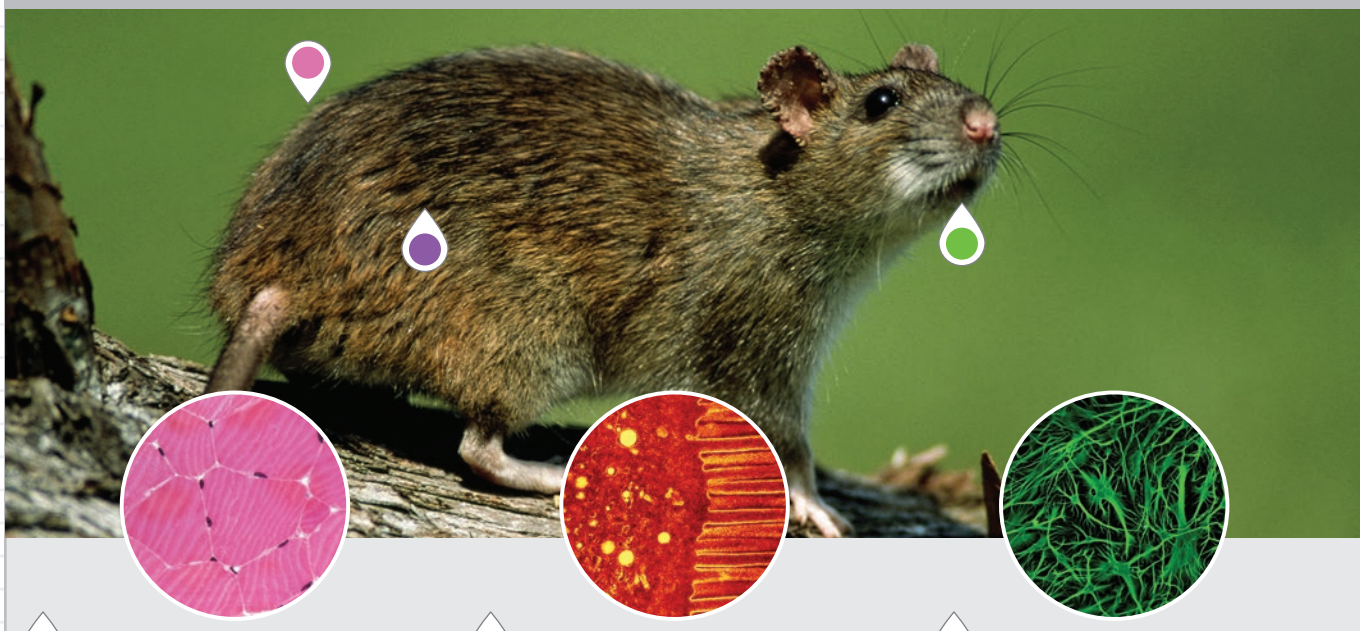
Think of an object or tool that you use every day, such as a pencil or water bottle. There is a relationship between the structure and function of these objects. The pencil is long and thin, so it's easy to hold. The water bottle has a hollow space to hold liquid and a smooth lip to drink from. Structure-function relationships exist at all levels of organization in an organism the same way.

Structure and Function of Cells and Tissues

All organisms are made of cells, but not all cells are the same. Cells are fit for the job they perform. For example, cells that engulf harmful particles in the body are flexible and can take any shape. But cells that form a protective barrier, such as the cells that cover a plant stem, are stiff and regularly shaped. A tissue has characteristics similar to the cell type that it is made of.

Structure and Function of Animal Tissues

Explore the photograph of the rat tissues to see how the structure relates to function.



Rats have long, flexible bodies that can squeeze through small holes. The skeletal muscle tissue is made up of muscle cells organized into stretchy fibers.

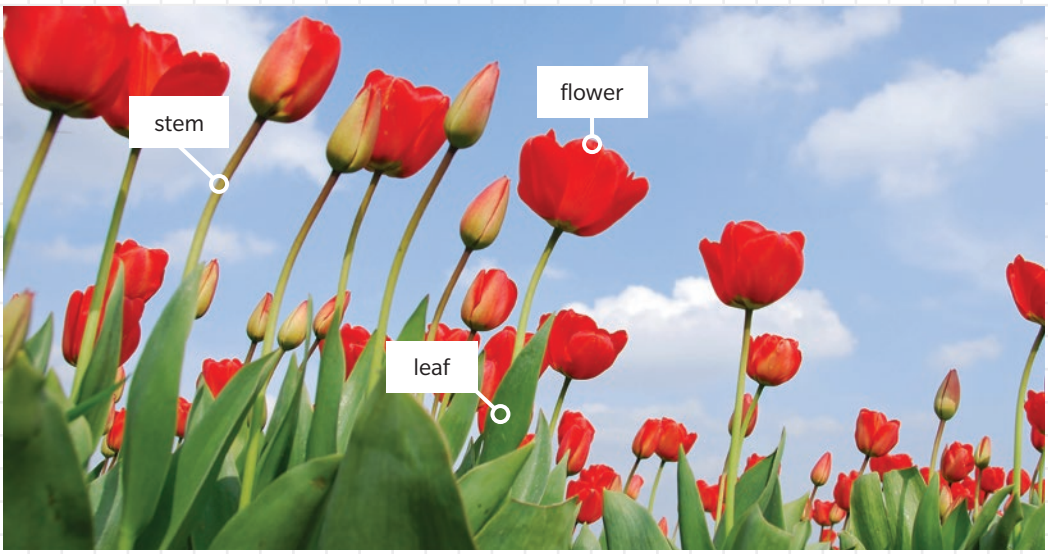
Rats are omnivores and will eat almost anything they can find. The tissue that lines the rat intestine has finger-like projections that increase the surface area.

Rats can remember food sources. The cells that make up the nervous tissue have long, branching extensions.

11. The tissue that lines the intestine helps release / absorb / break down nutrients by increasing the intestinal surface area. The long extensions of nervous tissue connect / ingest / destroy the cells in the brain and other parts of the body. The muscle cells are organized into flexible fibers because muscle tissue elongates and absorbs / protects / contracts.

Structure and Function of Organs

Just as the structure of a cell or tissue relates to its function, the structure of an organ relates to the function it performs. For example, some organs are shaped like hollow tubes to transport materials, such as the vessels that carry blood throughout your body. Others are sac-like to hold materials, such as your stomach that stores food and your lungs that expand to hold air.



Tulip flowers are organs that contain the structures the plant uses to reproduce. They come in a wide variety of shapes and colors.

12. Look at the photo of the tulip. Record your observations about the structures of the organs in the tulip shoot system.

Organ	Structural Observations	Functions
stem		transports nutrients and stores water, supports plant
leaf		captures sunlight for making nutrients, regulates water loss
flower		attracts animal pollinators

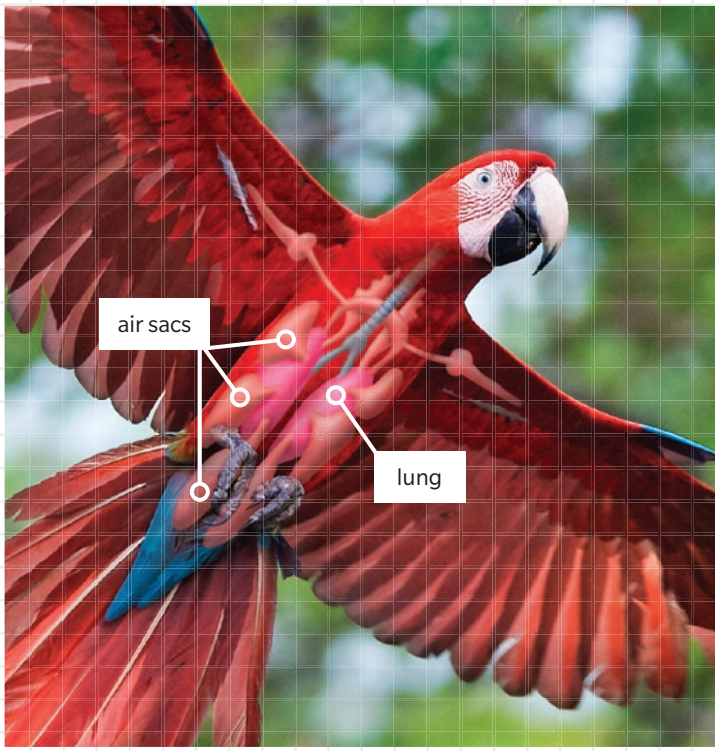
13. Leaves are made of a protective tissue that protects against water loss, ground tissue for support and storage, and transport tissue to move water and nutrients. Compare and contrast the thickness of the protective tissue you would expect to find on a leaf of a plant that lives in a wet habitat with the leaf of a plant that lives in a dry habitat.

Structure and Function of Organ Systems

Most organisms have organ systems that perform specialized functions. For example, a respiratory system is an animal organ system that takes in oxygen and releases carbon dioxide. Some animals that do not have a respiratory system simply exchange these gases through their skin. Animals that have a more complex respiratory system are able to exchange gases more effectively because specialized organs are working together.

14. Birds have air sacs and lungs. When birds breathe in / out, oxygen-rich air fills the lungs and air sacs. When birds breathe in / out, the oxygen-poor air leaves the lungs, and stored fresh air enters the lungs from the air sacs. This means that birds always have a supply of oxygen- rich / poor air.

15. Describe how the structure of the bird respiratory system provides the energy the bird needs for flight.



Scarlet macaws fly long distances to find fruit, nuts, and insects.

Language SmArts
Relate Cells to Organ Systems

16. Develop an argument that explains how an organism is made up interacting body systems, which are all made up of cells. In your argument, explain how each level of organization is made up of a system of interacting parts.

Analyzing Body System Interactions

Body Systems Interact to Perform Functions

Organisms need to process nutrients and take in oxygen. They need to move to find food and mates, avoid predators, and travel to warmer temperatures. In multicellular organisms, body systems work together to perform functions. The coordination of systems gives an organism a greater variety of possible functions and responses.

Sailfish are the fastest fish in the ocean. These three sailfish are working together to hunt a school of sardines.

17. Look at the photo of the sailfish. Think about what these organisms need, and how they respond to their environment. Record your ideas in the table.

Need	Response
food	
	swim faster
warm up	
	travel to different location

EVIDENCE NOTEBOOK

18. In the cow, food travels through four different stomach compartments so that it can be fully broken down. What factor do you think contributes to the structure of the cow's digestive system? Record your evidence.

Human Body Systems

19. When you perform an activity, which organ systems are involved? Look at the photographs of people involved in different activities. Decide which organ systems are working together to perform the function shown.

The **circulatory system** delivers nutrients and oxygen to all cells in the body. It carries carbon dioxide and other waste products away from the cells.

The **respiratory system** takes in oxygen and releases carbon dioxide as we breathe.

The **muscular system** moves bones, causes the heart to beat, and moves food through the digestive system.

The **skeletal system** supports the body, protects organs, allows movement, and makes blood cells.

The **nervous system** controls body movement and coordinates communication between the brain and the environment.

The **digestive system** breaks down food into essential nutrients and expels solid waste from the body.

The **excretory system** removes liquid wastes from the body.

A. The muscular / digestive and excretory / skeletal systems allow the arms to move, spinning the wheels of this bike.

B. The respiratory/excretory and nervous/circulatory systems allow this student to breathe and read music.

C. Body functions slow down as you sleep, but they do not stop! For example, the digestive / excretory system continues to break down food, and the muscular / circulatory system continues to deliver nutrients throughout the body.

20. Hummingbirds have small, weak feet and rely on their strong wings to move from one place to another. Describe how a disease affecting the muscular system would affect the other body systems of the hummingbird.

This hummingbird's wings beat more than 50 times per second!

Engineer It

Compare Natural and Designed Systems

This pulp slurry will eventually be made into paper for newsprint.

Humans use an industrial process to digest plant matter for use in products, such as paper. The papermaking process begins by feeding wood chips cut from trees into a tall, cylindrical tower that has multiple cooking chambers. The cooking process uses chemicals, heat, and pressure to break down the fibers in the wood to make a material called *pulp*. After passing through all the cooking chambers, the pulp is sent to a washer to wash away the cooking liquid. The pulp is spread out on a screen where it is bleached and dried. The pulp is then cut, stacked, and ready for processing into paper.

21. What need does the plant digester fill? How does this compare to the need that an animal's digestive system fills?

22. Make a diagram that shows the steps of making paper into pulp. How do you think this process compares to the digestion of food by animals?

Continue Your Exploration

Name: **Date:**

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

Biomimicry

- **Hands-On Labs**
- **Engineering Organs and Tissues**
- **Propose Your Own Path**

Go online to choose one of these other paths.

No matter what you want to do with a machine or process, there is a good chance that there is an organism that does it naturally. *Biomimicry,* or *biomimetics,* uses design solutions found in nature to solve human design problems. For example, researchers are always looking for ways to make a strong yet flexible fiber. One of the strongest known materials is spider silk. Scientists study spider webs to find out what the silk is made of. If researchers could manufacture synthetic spider silk, it could be used in a wide range of applications. Surgery sutures and wound covers, artificial ligaments and tendons, protective clothing, and fishing nets are some examples of the potential applications using synthetic spider silk.

1. Why do you think more scientists today are turning to nature to solve engineering and design problems? Select all that apply.

A. Clean and sustainable design solutions could help solve environmental issues, such as pollution.

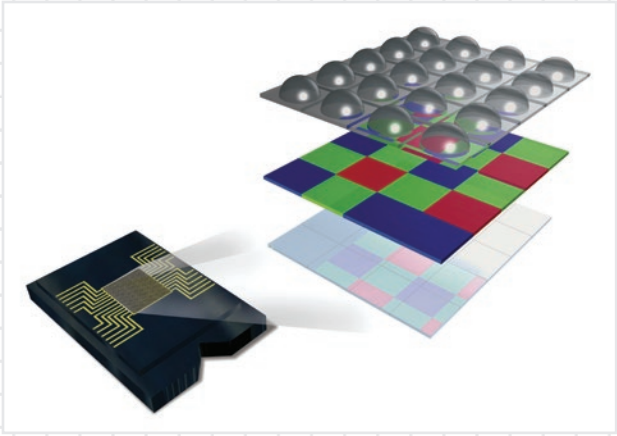
B. Scientists are running out of ideas for design and engineering solutions.

C. Greater understanding of the natural world has led to the discovery of new possibilities for design solutions.

The silk of spiders is incredibly strong, lightweight, and flexible. Scientists hope the silk will replace human-made materials that are not as strong, not as flexible—and not as environmentally friendly.

Continue Your Exploration

Scientists have discovered that brittle stars are covered in thousands of microscopic lenses that may help them avoid predators. These lenses transmit light more perfectly than any human-made lens.



The biomimetic lenses based on the brittle star lens structure are soft, providing better fine-tuning and complexity than conventional hard lenses. The microlenses shown here are part of a device that is used in digital cameras.

2. Engineers often use designs that mimic shapes found in nature, such as flippers, wings, and beaks. Construct an argument that supports the use of structure-function relationships found in nature in engineering and design. Use the examples as evidence.

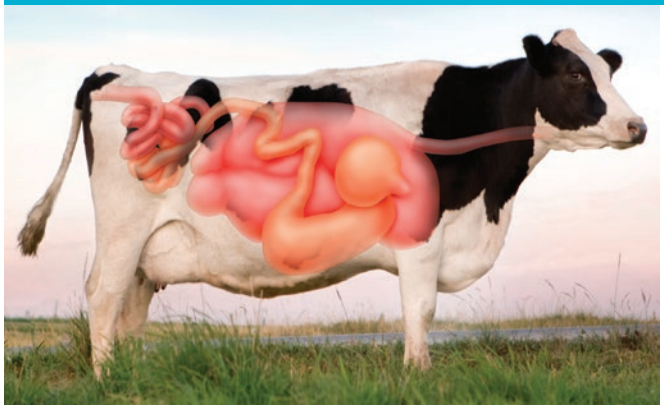
3. Sustainability experts help communities, companies, and governments adopt operating practices that are environmentally friendly. They seek to reduce pollution and waste and to increase recycling of resources. How might sustainability experts apply biomimicry to their field?

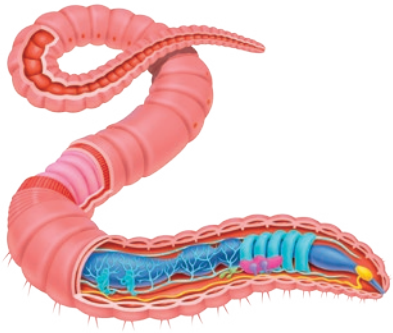
4. Collaborate Brainstorm characteristics of organisms that you think could be used to solve design problems. Choose one idea and make a sketch with an explanation of the connection to nature and the problem it addresses. Review the ideas of other groups. Practice skepticism as you evaluate their claims for how their solution would solve a design problem.

Can You Explain It?

Name: **Date:**

How can systems with such different structures perform the same function?





EVIDENCE NOTEBOOK

Refer to your initial explanation about the digestive systems and the notes in your Evidence Notebook. These can help you construct an explanation for why these systems have different structures.

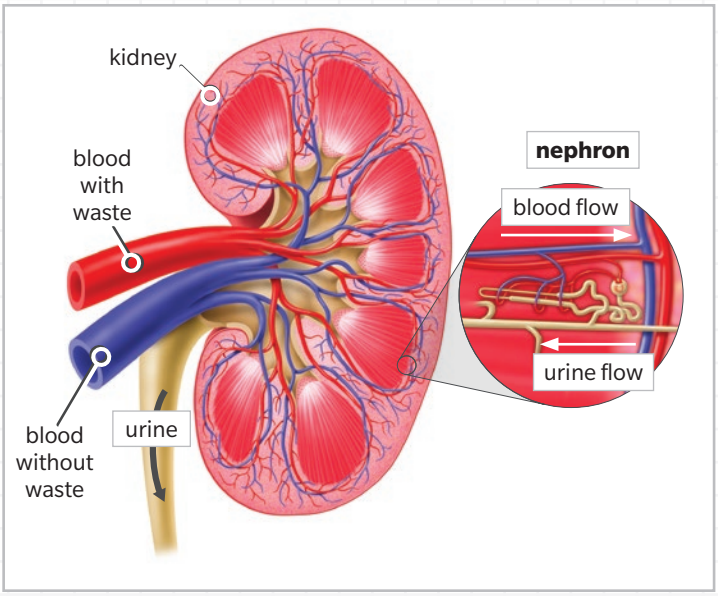
1. State your claim. Make sure your claim fully explains the similarities and differences between the two systems.

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.

Study the diagram of the kidney to answer Questions 3–4.



3. Each kidney contains more than 1 million filtering structures called *nephrons*. The nephron is made up of cells that work together. Based on the information, which statement is true?

A. The nephron can be defined as an organ.

B. The kidney can be defined as an organ system.

C. The nephron can be defined as an organ system.

D. The nephron can be defined as a tissue.

4. Kidneys are organs in the urinary system that remove waste products from the blood. The urinary system is a subsystem of the excretory / digestive system. The urinary system works with the circulatory / digestive system to remove liquid waste from the body.

Use the photograph of the plant to answer Questions 5–6.

5. The underground portion of this plant is the root system. Each root is a(n) tissue / organ that absorbs water and nutrients from the soil. These materials are transported by the stem, a(n) tissue / organ that is part of the shoot system in the plant.

6. What level of organization is a single leaf of this plant?

A. cell

B. tissue

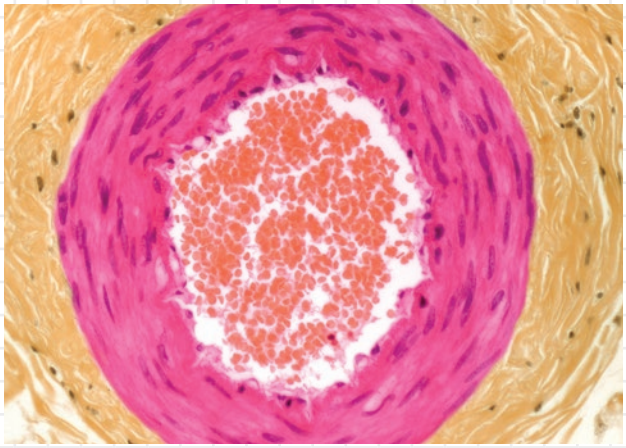
C. organ

D. organ system

Interactive Review

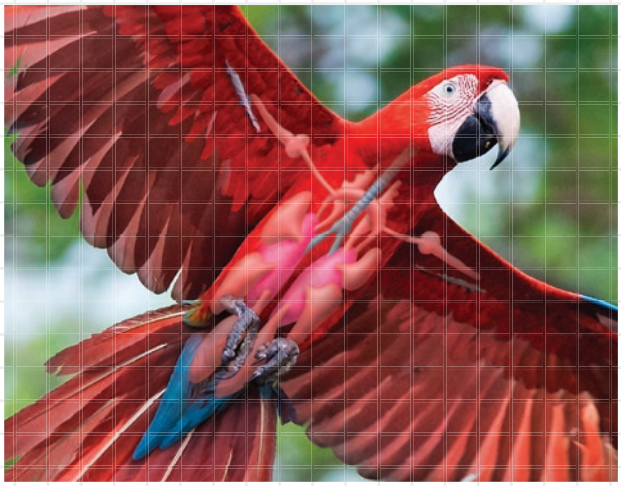
Complete this section to review the main concepts of the lesson.

Cells, tissues, organs, and organ systems are the levels of organization in living things.



A. How does having multiple levels of organization benefit a multicellular organism?

A relationship exists between structure and function.



B. Describe how structure is related to function in an organism.

Body systems work together to perform all the functions necessary for the survival of an organism.

C. Explain why the failure of one organ or organ system can affect the function of other body systems in an organism.