

Body Systems

Strand	Life at the Systems and Organism Level
Topic	Investigating the structure and function of body systems
Primary SOL	BIO.4 The student will investigate and understand life functions of Archaea, Bacteria, and Eukarya. Key concepts include b) maintenance of homeostasis; d) human health issues, human anatomy, and body systems.
Related SOL	BIO.1 The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which a) observations of living organisms are recorded in the lab and in the field; h) chemicals and equipment are used in a safe manner; i) appropriate technology, including computers, graphing calculators, and probeware, is used for gathering and analyzing data, communicating results, modeling concepts, and simulating experimental conditions.

Background Information

Animals are made up of complex systems of cells, which must be able to perform all of life's processes and work in a coordinated way to maintain a stable internal environment. Early in an animal's development, groups of cells specialize and differentiate into a number of specialized cells and tissues. **Tissues** are groups of cells that may be held together by a matrix and that are similar in structure and function. The four primary groups of tissues are epithelial, connective, muscular, and nervous.

Different tissues functioning together for a common purpose are called an "organ" (e.g., stomach, kidney, lung, heart). All vertebrates share the same basic body plan, with tissues and organs functioning in a similar manner. **Organ systems**, also called "**body systems**," are composed of various organs working together to accomplish a coordinated activity. For example, the stomach, small intestine, and large intestine together play a role in digestion; therefore, they are parts of the digestive system.

The body systems include the following:

- The **skeletal system**, made up of bones, cartilage, and joints, is the framework of the body. It protects internal organs, stores minerals, and provides places for muscles to attach.
- The **muscular system** is composed of skeletal, smooth, and cardiac muscle tissue. Skeletal muscle, attached to the skeleton with dense strips of connective tissue called "tendons," is responsible for the movement of body parts. Smooth muscle, sometimes called "visceral muscle," is found in internal organs (e.g., lining the walls of many blood vessels, making up the iris of the eye, forming the wall of the gut). Cardiac muscle forms the bulk of the heart, which controls blood circulation.
- The **circulatory system**, made up of the blood, blood vessels, and heart, is the body's transportation system, moving oxygen, carbon dioxide, nutrients, wastes, hormones,

vitamins, minerals, and water throughout the body. It also aids in regulation of body temperature.

- The **respiratory system** includes an animal’s nose, lungs, and trachea. The respiratory system brings air into the animal and releases waste carbon dioxide back into the air.
- The **digestive system** converts foods to simple substances that can be absorbed and used by the cells of the body. It is composed of the mouth, pharynx, esophagus, stomach, small intestine, and large intestine and is aided by several accessory organs—the liver, gall bladder, and pancreas.
- The **excretory system**, made up of the skin, lungs, sweat glands, and kidneys, removes metabolic wastes from the body. The kidneys are responsible for eliminating the bulk of wastes from the human body.
- The **immune system** protects against infection and disease.
- The **reproductive system** generates reproductive cells (gametes) and provides a mechanism for them to be fertilized and maintained until the developing embryo can survive outside the body. The primary reproductive organs are the ovaries (female) and the testes (male).
- The **nervous system** regulates and coordinates the body’s responses to changes in the internal and external environments. Major structures of the nervous system are the brain, spinal cord, and nerves.
- The **endocrine system** consists of the hypothalamus, pituitary, thyroid, parathyroid, and adrenal glands, as well as the pancreas, ovaries, and testes. This system helps to maintain homeostasis, regulate temperature, and control growth, development, metabolism, and reproduction by secreting and releasing hormones.
- The **integumentary system**, composed of the skin, hair, nails, and sweat and oil glands, is the first line of defense in protecting the body. It protects against injury, infection, and fluid loss and also aids in temperature regulation.

On July 21, 2004, the Virginia Board of Education approved the “Guidelines for Alternatives to Dissection.” This was pursuant to House Bill 1018 of the 2004 General Assembly that amended the *Code of Virginia* to include § 22.1-200.01 directing the Board of Education to establish guidelines to be implemented by school divisions for alternatives to animal dissection. The General Assembly’s legislation states the following:

§ 22.1-200.01 Alternatives to animal dissection

Local school divisions shall provide students with alternatives to animal dissection techniques within the relevant public school curriculum or course. The Board of Education shall establish guidelines to be implemented by local school divisions regarding such alternative dissection techniques. Such guidelines shall address, but shall not be limited to, (i) the use of detailed models of animal anatomy and computer simulations as alternatives to dissection; (ii) notification of students and parents of the option to decline to participate in animal dissection; and (iii) such other issues as the Board deems appropriate.

A list of free, Web-based dissection simulations is available on the Virginia Department of Education’s Web site. If you have questions regarding the “Guidelines for Alternatives to Dissection,” please contact the Virginia Department of Education’s Office of Standards, Curriculum, and Instruction at (804) 225-2676.

Materials

- Internet access
- Dissection manuals
- Lab aprons
- Safety glasses
- Disposable gloves
- Dissection kits (scalpel, scissors, needles, pins)
- Dissection trays
- Preserved fetal pigs
- Twine
- Zip-top plastic bags
- Bone saw (optional)
- Digital camera (optional)
- Copies of the three attached handouts
- Coloring utensils

Vocabulary

body system, circulatory, digestive, endocrine, excretory, immune, integumentary, muscular, nervous, organ, organ system, reproductive, respiratory, skeletal, tissue

Student/Teacher Actions (what students and teachers should be doing to facilitate learning)

Introduction: The Pig—Indirect Instruction¹

The domestic pig, *Sus scrofa domesticus*, belongs to class *Mammalia* (mammals), which has hair and mammary glands. The pig is a member of order *Artiodactyla*, the even-toed ungulates. It shares this order with the cow and deer. It is an omnivore, eating both plant and animal matter. The life span of the pig is 15 to 20 years. An adult pig may weigh up to 900 lb. (400 kg).

During this inquiry activity, you will be a facilitator, answering questions and helping students find correct answers, but you will not teach them the parts of the pig; instead, you will help them discover and learn the parts on their own. After becoming “specialists,” students will share their knowledge with their classmates, therefore becoming teachers themselves. Through this approach to dissection, students will become heavily involved in their learning and increase their level of understanding. This is the essence of the inquiry-method of learning.

1. Explain to students that they will be dissecting a pig and will be able to see most, but not all, of the pig’s major body systems. (Systems not covered in this dissection are the muscular, skeletal, integumentary, and endocrine systems.)
2. Group students into pairs. Assign a body system to each pair, and tell each pair which organs and functions they should find within their assigned system. For example:
 - All pairs: external anatomy—determination of male or female characteristics
 - Pair 1: respiratory system—larynx, trachea, esophagus, bronchus, lung, diaphragm

¹ Trish Patrick, “Instruction Using the Earthworm and the Pig,” *Carolina Tips* 67, 1 (Spring 2004), http://www.carolina.com/text/pdf/preserved/Instruction_using_the_Earthworm_and_Pig.pdf. This article covers the indirect method of instruction.

- Pair 2: circulatory system—heart, pericardial membrane, right ventricle, left ventricle, right atrium, left atrium, aortic arch
 - Pair 4: excretory system—kidney, ureter, urethra, urinary bladder
 - Pair 3: digestive system—palate, esophagus, liver, gallbladder, stomach, pancreas, intestine, mesentery, duodenum, colon, rectum
 - Pair 5: nervous system (optional)—cerebrum, pons, medulla, corpus callosum, cerebellum, spinal cord. (Dissecting the cranium will most likely require a bone saw.)
3. Remind students that they will be responsible for gathering information and teaching others about the organs and functions of their assigned body systems. Provide them with opportunities to use lab manuals, other science books, and Internet sites to find information on how to dissect a pig to study their assigned systems.
 4. Ask each student pair to create a dissection plan that includes:
 - Procedures to be used to expose and/or dissect the structures in their assigned body system.
 - Outline of a presentation to share their discoveries with the rest of the class, including plans for use of photos taken with a digital camera, if available.It is important that you review and approve these plans prior to dissection.
 5. Before beginning the dissection, identify the appropriate tools, and lead a student discussion of the important issues. (*CAUTION: Safety glasses and lab aprons are mandatory.*) (Students may use scalpels, but dissection can be done with scissors.)
 6. Because skin incisions for beginning the dissection are different for male and female pigs, have students first use lab manuals to determine the sex of their pigs and how they should proceed. At this point, have students tell you the sex of their pigs and explain how they plan to begin dissection.
 7. Have students wash the specimens, if this has not already been done, to remove any remaining preservative fluid, and place the specimens in dissection trays.
 8. Direct students to tie a piece of twine to the front and back legs on one side of the animal and then pass the twine underneath the dissection pan to the other side and tie it to the front and back legs on the other side to hold the legs apart.
 9. Have students use scissors (*not a razor blade or scalpel*) to make incisions to open the thoracic and abdominal cavities. Instruct them to keep the scissors parallel to the skin surface to prevent damage to the internal organs. Direct them to remove the flaps of skin to reveal the internal organs. While most of a fetal pig’s skeleton is still cartilage, bone development had started in the chest or thoracic area, which means that more careful force will be required to cut through the sternum (breast bone).
 10. Have students follow their previously approved dissection plans to continue dissections.
 11. When dissections are complete, have students dispose of materials based on procedures found in your school division’s chemical hygiene plan and/or to the county’s safety manual.
 12. Have student “specialists” teach the rest of the class what they learned about their assigned systems and organs, following their previously approved presentation plans.

Assessment

- **Questions**
 - What organelles within a cell perform similar functions to the circulatory system?
 - What organelles within a cell perform similar functions to the brain?
 - What organelles within a cell perform similar functions to the digestive system?
 - How are structure and function related?
 - What structures are found in a fetal pig but not in a human? What structures are found in a human but not in a fetal pig?
 - How are the structures in a fetal pig different from those of an adult pig?
- **Journal/Writing Prompts**
 - Choose one of the major body systems of the mammalian body, and draw it in detail. Label five key organs and/or structures of this system.
 - Choose an organ or structure that is part of your assigned body system. Explain its function. Identify other organs and/or structures that work with this structure. Identify other structures that are directly attached to it, and explain their functions. Discuss what life would be like for the human if this structure were absent.
- **Other**
 - Have students identify at least 12 major internal organs in the fetal pig.
 - Have students complete a practical exam in which pins are placed into the pig's organs before class, and students must identify these organs/structures and their functions.
 - Have students complete the attached Functions of Organs activity sheet (for example, Dorsal nerve cord — Carries nerve impulses from brain to body, and vice versa — Nervous system).
 - Have students complete the attached Internal Anatomy Coloring Sheet.
 - Have students complete the attached Body Systems activity sheet.

Extensions and Connections (for all students)

- Have each student write a 200-word composition describing the nervous, circulatory, excretory, and respiratory systems of the fetal pig and comparing and contrasting these systems with the same systems in humans.
- Have students research one current medical application being used for a specific organ or system. Require them to use at least one scientific journal as a resource.

Strategies for Differentiation

- Have students create T-shirts to illustrate a body system or structure of their choice. Shirts should be designed so that when worn, organs are shown in the correct locations.
- Have students create a model of a body system, using either sewing materials or various recycled materials.

Functions of Organs

State at least one function of each organ listed below, and indicate the body system to which the organ belongs.

Organ	Function	Body System
Brain cerebellum		
Brain cerebrum		
Brain medulla		
Coronary arteries		
Diaphragm		
Dorsal nerve chord		
Esophagus		
Gall bladder		
Heart		
Kidneys		
Large intestine		
Liver		
Lungs		
Pancreas		
Pyloric (stomach) sphincter valve		
Small intestine		
Spleen		
Stomach		
Testes/ovaries		
Thymus gland		
Ureters		

Body Systems

Circulatory System	Skeletal/Muscular Systems	Respiratory System
Digestive System	Excretory System	Endocrine System
Immune System	Integumentary System	Nervous System

- Draw a small picture in a bottom corner of each box to help you recall the system.
- Write the name of each item listed below in the system box to which it belongs:

1. antibodies	8. cranium	15. humerus	22. quadriceps
2. arteries/veins	9. eyes	16. intestines	23. skin
3. biceps	10. femur	17. kidneys	24. stomach
4. bladder	11. gonads	18. lungs	25. T cells
5. blood	12. hair	19. lymph nodes	26. thyroid gland
6. brain	13. heart	20. nails	27. trachea
7. cerebellum	14. hormones	21. nerves	28. veins

3. Write each function listed below in the system box that *best* exemplifies it.
- Acquires nutrients and releases waste
 - Acquires oxygen and releases carbon dioxide
 - Defends against pathogens
 - Maintains homeostasis
 - Performs osmoregulation
 - Protects against desiccation; defends

Internal Anatomy Coloring Sheet

1. Find the **trachea**. It is a tube of ringed cartilage that connects the mouth to the lungs. Because it is made of cartilage, it cannot regenerate (just like your ears); if you puncture it, you will forever have a hole in your throat! Color the trachea BLUE.
2. Find the **thyroid gland**. It wraps around the trachea. It is responsible for regulating your metabolism. Strangely enough, President Bush, Mrs. Bush, and their dog Millie all had thyroid problems, though no one ever found a cause. Color the thyroid gland PINK.
3. Find the **heart**. It looks like a fist centered between the lungs. Its function is to pump blood throughout the body. Can you believe your heart contracts 100,000 times in just one day? Color the heart RED.
4. Find the **lungs**. There are two of them. Their function is to oxygenate the blood. Did you know that your left lung is smaller than your right lung to accommodate for your heart? Color the lungs YELLOW.
5. Find the **diaphragm**. It is a thin sheet of muscle just below the lungs that separates the thoracic and abdominal cavities. The diaphragm is responsible for your ability to take in air and expel it from your lungs. When you get the hiccups, it is because your diaphragm is contracting irregularly. Color the diaphragm PURPLE.
6. Find the **spleen**. It sits just above the right kidney. It plays an important role in the immune system. If part of the spleen is removed, sometimes it can regenerate itself! Color the spleen ORANGE.
7. Find the **pancreas**. It is “dotted” in the diagram because it is found behind the liver and stomach. The pancreas creates enzymes that break down fats and hormones to regulate blood sugar. Diabetics have pancreas problems in that it produces too much or too little insulin. Color the pancreas GREY.
8. Find the **liver**. In a human being, it is the size of a football and weighs more than 3 pounds! The liver produces bile, a greenish fluid that breaks down fats and helps filters all your blood, among many other jobs. Color the liver BROWN.
9. Find the **gallbladder**. It is tiny and nestled in the lobes of the liver because it stores the bile that the liver creates. Bile helps break down fats. The gallbladder is actually green, so color the gallbladder GREEN.
10. Find the **stomach**. It looks like a sack. When you eat, your food stays in your stomach for about three hours before moving on to the small intestine. It has a pH of about 2.0 and creates the enzyme pepsin to break down proteins. Color the stomach BLUE.
11. Find the **small intestine**. It is a coiled tube about 6m (20 feet!) long and absorbs nutrients from broken-down food. It is lined with villi, small finger-like projections that increase the surface area to absorb the maximum amount of nutrients. Color the small intestine PINK.
12. Find the **large intestine**. It is shaped like an upside down U and does not perform digestion. The large intestine contains E. coli bacteria to remove all the water from undigested food. Can you believe your food can stay in your large intestine for up to 24 hours? Color the large intestine ORANGE.

13. Find the **appendix**. It is a “hook” on the left side of the large intestine. The appendix is vestigial in humans, meaning we no longer use it, so it can be removed. The appendix was originally used to help humans digest raw meats. Color the appendix RED.
14. Find the **kidneys**. There are two, and they are shaped like kidney beans. They filter your blood and remove waste, creating urine. The kidneys filter almost 50 gallons of blood every day! Color the kidneys YELLOW.
15. Find the **bladder**. It is the lowest organ in the diagram. The kidneys move urine into the bladder for storage, and the bladder can stretch enough to hold a pint of urine. Color the bladder PURPLE.

