



Pig Anatomy Organ Systems Unit Plan

GRADE 12



Animal Welfare Institute

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Curriculum Alignment

This lesson plan can be used to create classes for Grades 12 based on the BC Science Curriculum. Specific Big Ideas covered in this lesson plan include:

GRADE 12

Organ systems have complex interrelationships to maintain homeostasis.

Organ Systems:

- Structure and function
- Structural and functional interdependence
- Maintenance of homeostasis

We have recommended specific virtual anatomy tools to use to get the most out of the lesson plans. You'll find links to those on page 9.

Learning Objectives

This unit plan is for a summary of pig anatomy and body systems. It can be condensed into one longer summary class, or used to delve deeper into each body system over multiple classes. It is intended for Grade 12 level but can be adapted for other grades depending on the level of detail covered.

By the end of the lesson students should be able to:

- Identify the major body systems of pigs and their major organs
- Explain the function of each major organ
- Describe the concept of homeostasis
- Explain how the major organ systems in pigs work together to maintain homeostasis

All About Pigs!

Use these notes to inform your class content, no matter what grade you're teaching!

Sus domesticus, or the domestic pig, is widely considered one of the most peaceful and non-aggressive animals known to humans. Pigs play an important role in managing ecosystems, provide sustenance for many cultures across the globe, and even appear in the Chinese Zodiac. They are extremely social creatures, forming close relationships with their pen mates, snuggling up with them, and staying in constant communication using meaningful grunts, squeals and oinks. Pigs are clean animals and they keep their toilet area far away from where they lie down, which is probably a good thing since they have such a keen sense of smell! In light of all this, it should come as no surprise that we like to look to our mammalian pig companions to help us better understand our relationship to them as vertebrates and to understand how our own bodies work. We're going to explore both the external and internal structures of pigs. Since pigs are so complex, we'll divide up our exploration into major organ systems, but we'll begin with information about external anatomy before working our way inside.

EXTERNAL ANATOMY

At the anterior, or head, end of the pig, you'll find the **snout**. The snout, or nose, is the main structure responsible for a pig's sense of smell. Two small holes in the tip of the snout called **nares** are responsible for bringing air into the nasal passageways for gas exchange when the mouth is closed. As mentioned before, pigs have a very keen sense of smell and can smell odours from up to seven miles away and 25 feet underground. A large round disk of cartilage inside gives the snout its shape and also provides a place for muscles to attach. This helps pigs to root underground for food. Around the mouth are the **lips**, which includes an indentation in the upper lip called the **philtrum**, which may play a role in aiding pigs smell. Humans also have a philtrum, which is the site where the nasomedial and maxillary bones fuse. Above the snout are two **eyes** used to take in visual stimuli. Each eye is surrounded by an upper and a lower **eyelid**, which are responsible for protecting the eye. Similar to frogs, pigs also have a **nictitating membrane**, found in the inside corner of the eye. This membrane is responsible for wiping debris from the surface of the cornea and to help moisten the eye. On either side of the head above the eyes are the pinna, or external ear flaps. These help to gather sounds from the environment and focus them into the inner ear to be interpreted by the brain.

There are two distinct regions of the pig torso: the **thorax** and the **abdomen**. The thorax houses the major life sustaining organs such as the **heart** and **lungs**. The abdomen houses **digestive organs**, as well as **excretory, urinary, and reproductive** organs.

On the ventral (or belly) surface of pigs there are several pairs of nipples or **mammary glands**. In females, these develop during the transition from juvenile to adult to produce milk for their young. They do not develop in males.

In males, the urogenital opening is located just below the **umbilical cord** (the structure through which the fetal pig receives nutrients from its mother during gestation—nutrients are passed through the arteries and veins contained within the umbilical cord). Most mammals have separate openings for the urogenital and anal openings. In female pigs, the posteriorly located (toward the rear) urogenital papilla houses a common location for an anterior **urethra** and posterior vaginal orifice. The urogenital opening provides an exit route for both liquid waste and sperm or eggs/offspring depending on the gender of the organism. Near the anus of male pigs is a swollen area where the **scrotum** resides. The scrotum houses and protects the **testes**. The anus is the posterior orifice located underneath the tail from which solid waste is excreted from the body.

Extending from the lateral regions, or sides, of the thorax and abdomen are four appendages: two **fore limbs** and two **hind limbs**. These take on the job of carrying the weight of the pig in its upright position. At the distal, or furthest point of each appendage, is a **hoof** on which the pig walks. Because of this, they are considered **unguligrade** or ungulates. Humans are considered **plantigrade** because we walk on the soles of our feet, while dogs and cats are **digitigrade** because they walk on their digits, or toes/fingers.

Before you get started, it's important to review some anatomical terminology with your students.

When studying any organism, scientists use directional terms to identify regions and parts easily. These terms are consistent throughout anatomy studies and are provided in the chart below. Be sure to revisit this chart with your students often.

Posterior	Back	Anterior	Front
Superior	Above	Inferior	Below
Caudal	Toward the bottom or tail	Cranial	Toward the top of the head
Proximal	Toward the trunk (abdomen)	Distal	Away from the trunk (abdomen)
Lateral	Away from the midline	Medial	Toward the midline
Dorsal	Back	Ventral	Front
Superficial	Closer to the surface of the body	Deep	Further from the surface of the body
Internal	On the inside	External	On the outside

Recommended Software and Other Education Tools

[3D Pig Anatomy app](#) by Biosphera
(also available via Google Play)

[Paper pig dissections](#) and worksheets

(These are great fun! We highly recommend trying to get these to your students even if you're teaching online)

Recommended Hardware/Workbooks

This inventory is for regular in-person classes. For responsible physical distancing use one tablet per student. If teaching online, screen share your own tablet or desktop with the Biosphera 3D Pig Anatomy app installed, and use electronic versions of our Pig Anatomy Workbook.

Six (or more) tablets

Six (or more) constructed pig paper dissections (3 male, 3 female) with blank legends printed out (the legends are part of the pig paper dissection bundle from Getting Nerdy with Mel and Gerdy, linked below) and the relevant numbers highlighted to focus students on the body systems/organs you want to cover. If teaching online we recommend trying to get paper pigs to your students somehow, whether you arrange for them to pick them up at the school, mail them, or have them print them at home—their homework can be to cut out their pig and stick it together before class (assembly instructions are included in the bundle from Mel and Gerdy).

Six (or more) printed copies of the Pig Anatomy Workbook (accompanies the 3D Pig Anatomy app)

Grade 12 Unit Plan Approach

If teaching regular in-person classes:

- Split students into 6 groups.
- Give each group x1 constructed paper pig dissection model to refer to, and a blank legend with highlighted numbers to indicate which sections to fill out (you'll need to prepare these ahead of time—the legends are part of the pig paper dissection bundle from Getting Nerdy with Mel and Gerdy, linked above)—the legend corresponds to the paper dissection and the apps will be used to help identify tissues and organs so that students can fill in the blanks. Give three of the groups a female paper pig, three a male paper pig.
- Give all groups one (or more) tablet(s) with the 3D Pig Anatomy app loaded and ready to use.
- For each body system, give the students 10–15 minutes per body system to explore the apps and fill in the blanks of their paper dissection legends (see detailed class plan below for more information).
- After each 15-minute time slot, have a 5-minute check in to make sure the students are sticking to the learning objectives and filling their legends out correctly.
- Close class with a focused discussion to recap what was learned, to discuss how the major body systems work together, and to make sure you've covered all the learning objectives.

If teaching physically-distanced classes:

- Use x1 tablet and x1 constructed paper pig dissection for each student. Give half the students a female paper pig, and the other half a male paper pig. Proceed as per directions above.

If teaching online:

- You can either mail the students the paper pig dissections, or ask them to print them at home or pick them up from the school if you want to include those in your lesson plan. If using the paper dissections, it's fun homework to ask the students to build their pig ahead of time by cutting it out and sticking it together before class—full assembly instructions are given as part of the Mel and Gerdy pig dissection bundle.
- Lead the students through a demonstration of each body system by screen sharing your own tablet or desktop with the 3D Pig Anatomy app by Biosphera installed.
- Take 10–15 minutes per body system.
- We recommend using Kahoot quizzes to check-in at the end of each body system to see what information the students learned, and to help make the classes fun and interactive!
- Students can follow along using an online version of our Pig Anatomy Workbook.

Teaching Notes

Introduction to topic:

Have a brief conversation about why you're choosing to use non-animal teaching methods rather than real animal specimens, and how this aligns with a culture of respect for animals.

Introduce the software and other materials you'll be using to teach pig anatomy. Give the students a roadmap of topics that will be covered: respiratory, circulatory, digestive, urogenital, nervous & sensory, endocrine and musculoskeletal systems, etc.

Opening questions to class:

1. What type of animals are pigs?
2. What are the major organ systems in mammalian bodies?
3. Does anyone want to have a go at explaining what homeostasis is?

Encourage students to bear the answers in mind as they go through the pig anatomy lessons.

Grade 12 Unit Plan: Pig Organ Systems

TOPIC: Organ systems have complex interrelationships to maintain homeostasis.

CONTENT: The different organ systems of pigs.

Goals	Students will be able to: <ul style="list-style-type: none">• Identify the organ systems of pigs and their major components• Explain the function and structure of each major organ• Explain how the major organ systems interact to create whole functioning organisms• Describe homeostasis and explain how organ systems help maintain it
Objectives	After this unit students will be able to state the organ systems and the major organs of each system. They will also be able to describe how organ systems maintain homeostasis, and explain key similarities and differences between pigs and humans.
Materials	<ul style="list-style-type: none">• 3D Pig Anatomy app by Biosphera• Pig Anatomy Workbook (to accompany 3D Pig Anatomy app)• Paper pig dissection by Getting Nerdy with Mel and Gerdy• Various anatomy worksheets (found within this document)
Introduction	Using the 3D Pig Anatomy app and the paper pig dissections, the teacher will introduce the various organ systems.
Development	Questions to support inquiry-based learning: <ul style="list-style-type: none">• How do organ systems interact with one another?• How does each organ system help maintain homeostasis?• How does the body maintain internal balance during exercise?• What is the advantage of having specialized tissues?
Practice	Going one organ system at a time (one system per lesson), students will work independently or in pairs to fill out the legend of their paper pig dissection by using the 3D Pig Anatomy app to help them identify the different organs.

Grade 12 Unit Plan Overviews

TOPIC	CONTENT
Homeostasis	Negative and positive feedback loops
Musculoskeletal	Bones, tendons, ligaments, muscles, fascia
Respiratory	Trachea, bronchi, bronchioles, alveoli, lungs, diaphragm
Digestive	Esophagus, stomach, small intestine, pancreas, liver, gallbladder and large intestine
Urogenital	Kidneys, ureter, bladder, urethra, ovaries and oviducts (female), uterus and vagina (female), penis and testes (male), epididymis, vas deferens and prostate (males)
Nervous	Brain, spinal cord, neurons.
Endocrine	Adrenals, hypothalamus, ovaries, pancreas, pituitary, testes, thyroid

Lesson 1: What Is Homeostasis?

TOPIC: Organ systems have complex interrelationships to maintain homeostasis. Homeostasis is maintained through physiological processes.

CONTENT: Homeostasis

Goals	Students will be able to: <ul style="list-style-type: none">• Explain the phenomenon of homeostasis• Give at least one example of positive feedback in a biological system• Give at least one example of negative feedback in a biological system
Objectives	After this lesson students will explain homeostasis and the importance of organ systems for maintaining internal balance.
Materials	<ul style="list-style-type: none">• 3D Pig Anatomy app by Biosphera• Various worksheets in this unit plan
Introduction	Using the 3D Pig Anatomy app the teacher will introduce the concept of homeostasis and give examples of specific organ systems that work to maintain internal balance.
Development	Questions to support inquiry-based learning: <ul style="list-style-type: none">• How do organ systems interact with one another?• How does each organ system help maintain homeostasis?• How does the body maintain internal balance during exercise?• What is the advantage of having specialized tissues?
Practice	Going one example at a time students will work independently or in pairs, using the 3D Pig Anatomy app, to identify key organs that play important roles in maintaining homeostasis.

What Is Homeostasis?

Homeostasis is the maintenance of the internal environment despite external changes.

The following parameters in the body need to be maintained:

- Blood temperature
- Blood glucose concentration
- Blood salt concentration
- Water potential of blood
- Blood pressure
- Carbon dioxide concentration

Receptors gather information about conditions inside and outside the body; for example, sensors in the skin detect changes in temperature. The body has thousands of specialized receptors that detect changes in the outside world. The **control center** (usually the brain) receives information from these receptors and compares this information with ideals at which the body functions best. When conditions move above or below a set point the control centre responds by sending messages through a communication system.

Communications systems, like the nervous and endocrine systems, carry messages to all parts of the body. These messages, in the form of nerve impulses or hormones, tell targets in the body how to respond to internal or external changes. A **target** is any organ, tissue or cell that changes its level of activity in response to a message. For example, in a cold environment a message might cause the muscles to start shivering to generate more body heat.

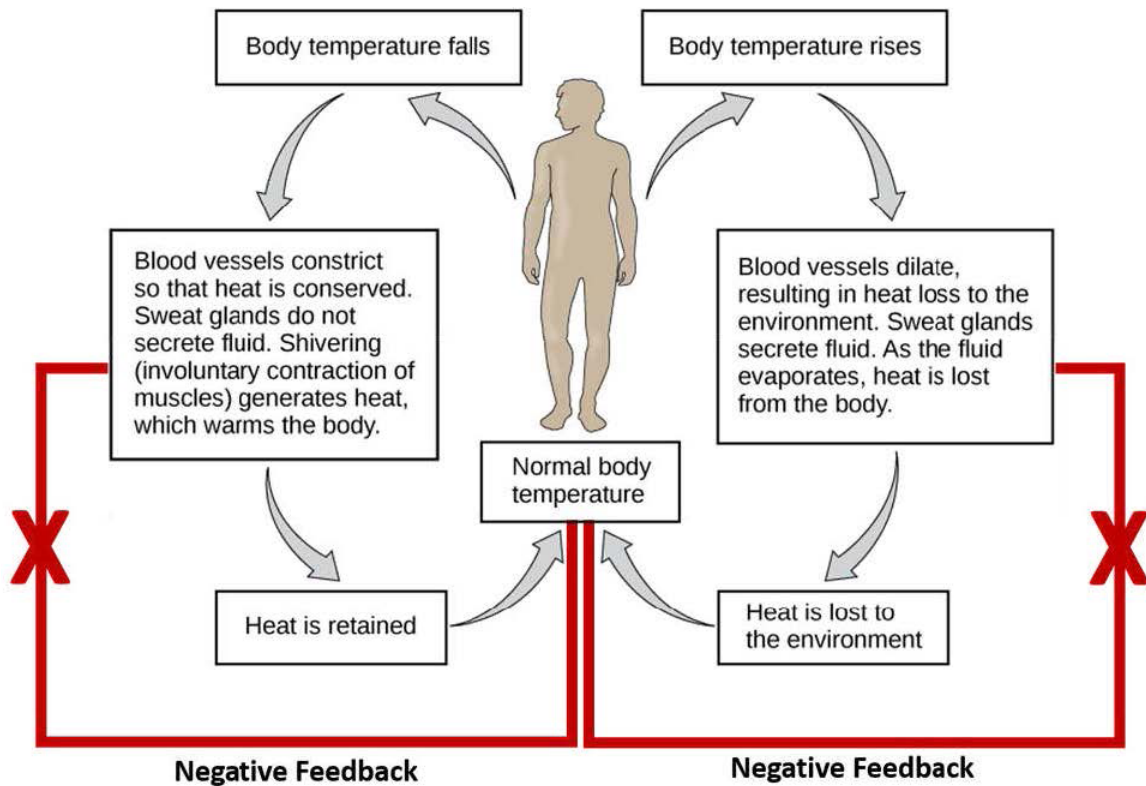
NEGATIVE FEEDBACK

Negative feedback is the reversing of a change in the internal environment. The control system in the body work together in a feedback loop. Most functions in the body a regulated by negative feedback loops, which maintain homeostasis by counteracting, or reversing, change to return conditions to their set points.

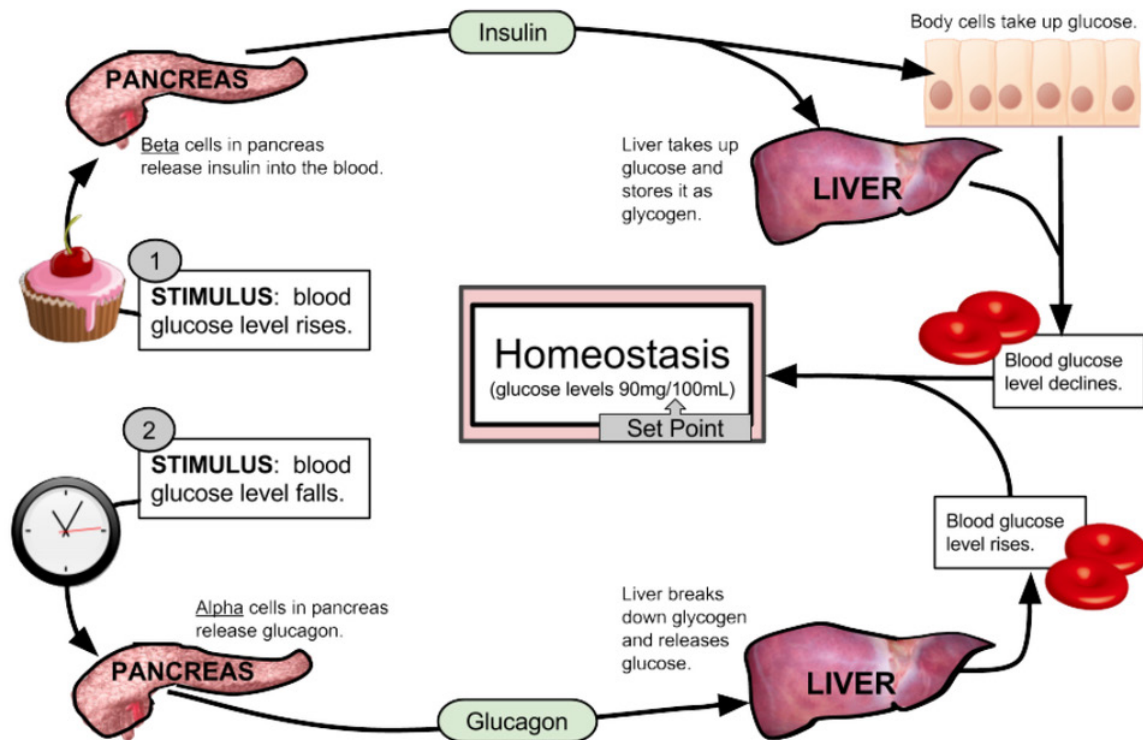
POSITIVE FEEDBACK

In positive feedback a control centre uses information from sensors to increase the rate of change away from the set points. This type of feedback is important whenever change is needed fast. For example, when you cut your finger positive feedback mechanisms increase the rate of change in clotting factors in the blood until the wound is sealed.

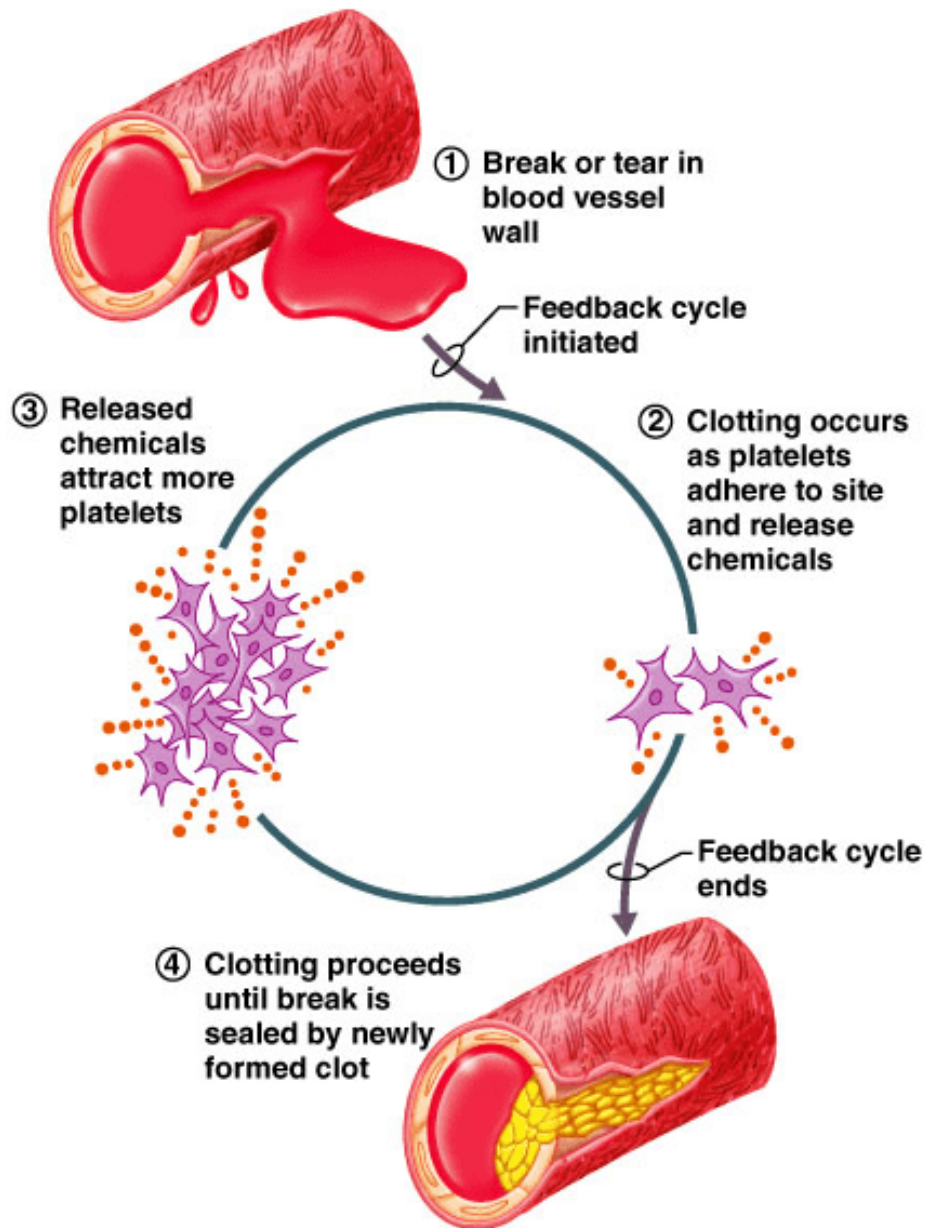
Homeostasis Example: Body Temperature (Negative Feedback)



Homeostasis Example: Blood Glucose (Negative Feedback)



Homeostasis Example: Blood Clotting (Positive Feedback)



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Lesson 2: Musculoskeletal System

TOPIC: Organ systems have complex interrelationships to maintain homeostasis. Homeostasis is maintained through physiological processes.

CONTENT: The pig musculoskeletal system.

Goals	Students will be able to: <ul style="list-style-type: none">• Identify the major organs/tissues of the pig musculoskeletal system• Explain the function and structure of each organ/tissue• Explain how the major organs/tissues in the musculoskeletal system work together to maintain homeostasis• Explain how the musculoskeletal system interacts with other organ systems
Objectives	After this lesson students will describe the structure and function of each organ/tissue in the musculoskeletal system. They will also explain how the musculoskeletal system maintains homeostasis, and explain key similarities and differences between pigs and humans.
Materials	<ul style="list-style-type: none">• 3D Pig Anatomy app by Biosphera• Pig Anatomy Workbook (to accompany 3D Pig Anatomy app)• Paper pig dissection by Getting Nerdy with Mel and Gerdy• Various anatomy worksheets (found within this document)
Introduction	Using the 3D Pig Anatomy app and the paper pig dissections, the teacher will introduce the musculoskeletal system.
Development	Questions to support inquiry-based learning: <ul style="list-style-type: none">• How do the musculoskeletal and nervous systems interact with one another?• How do the musculoskeletal organs/tissues help maintain homeostasis?• How does the musculoskeletal system maintain internal balance during exercise?• What is the advantage of having specialized musculoskeletal tissues?
Practice	Going one musculoskeletal organ/tissue at a time, students will work independently or in pairs to fill out the legend of their paper pig dissection by using the 3D Pig Anatomy app to help them identify the different organs/tissues.

Musculoskeletal System

Bones	The major functions of the bones are body support, facilitation of movement, protection of internal organs, and the production of red blood cells.
Tendons	A fibrous connective tissue which attaches muscle to bone.
Ligaments	A fibrous connective tissue which attaches bone to bone.
Muscles	Muscles allow a pig to move, vocalize and chew. They control heartbeat, breathing, and digestion. Other seemingly unrelated functions, including vision, also rely on the muscular system. There are three types of muscles: skeletal (consciously controlled), smooth (lines blood vessels and organs) and cardiac (located only in the heart).
Fascia	A connective tissue that surrounds muscles, groups of muscles, blood vessels, and nerves, binding some structures together while permitting others to slide smoothly over each other.

During check in:

Highlight key similarities between pigs and other species, especially humans:
Same major components and functions.

Highlight key differences between pigs and other species, especially humans:
Pigs lack a clavicle (collar bone).

Development question:

- How does the musculoskeletal system interact with the nervous system?
- What is the advantage of having specialized musculoskeletal tissue?
- How does the musculoskeletal system help maintain homeostasis?

Musculoskeletal System

Pigs are quadrupeds, which means that they walk on four legs. As such, their skeletal and muscular systems are adapted for living life in this way. Since humans and pigs share the characteristics of being both vertebrates and mammals, their skeletal system is very similar. In fact, every bone is the same, with the exception that pigs lack a clavicle, or more familiarly, a collarbone. Pigs can also have anywhere from 51–56 **vertebrae** (humans have 33). The **cervical vertebrae** attach to the skull and support the head and neck of the pig. Next are 14 to 15 **thoracic vertebrae** to which the ribs attach. Since there are 14–15 vertebrae, there are 14–15 **ribs** that make up the rib cage. The **sternum** is the central meeting point of the ribs and is comprised of three parts—an anterior portion called the **manubrium**, a central portion called the **gladiolus**, and a cartilaginous posterior portion called the **xiphoid process**, which also serves as an attachment point for abdominal muscles. Ribs that attach directly to the sternum are called true ribs. Ribs that attach to the intercostal cartilage before reaching the sternum are considered false ribs. The intercostal cartilage provides flexibility to the rib cage so that it can expand and contract with each inhalation and exhalation.

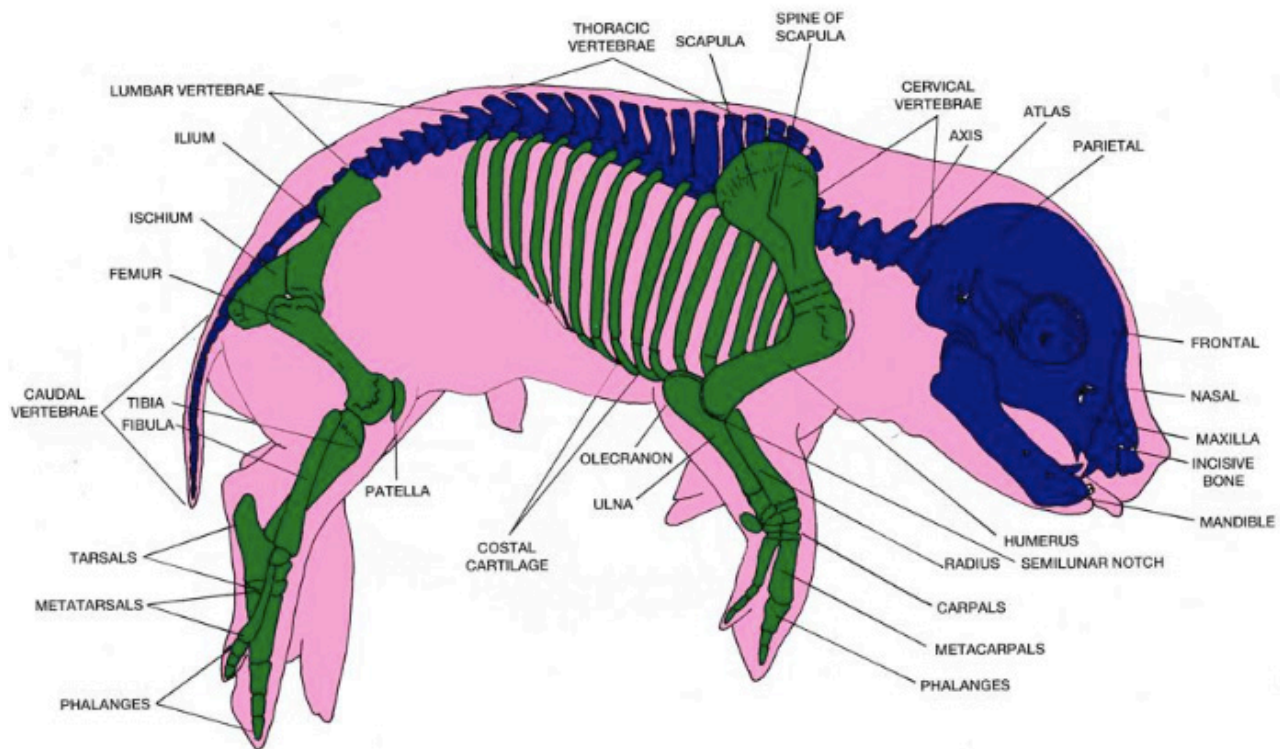
Six to seven **lumbar vertebrae** follow in the lower back/abdominal area and attach to the **pelvic girdle** which protects some of the digestive organs and reproductive organs as well as provides the point of attachment for the hind limbs. Four fused **sacral vertebrae** make up the dorsal (back) portion of the pelvic girdle and lead into 20–23 **caudal vertebrae** which make up the tail. Each vertebra has several processes (bumps), facets (flat spots) and/or foramen (holes) on the surface of it. These all play different roles in providing the body with places for muscles to attach, bones to touch, and nutrients to be supplied to the cells of the bones.

The musculature of pigs is attached to bones via tendons. There are three types of muscle tissue: **cardiac** (heart), **skeletal** (used to move the body) and **smooth** (lines organs and vessels). The skeletal muscles identified in this model all function in a directional movement of the organism. Here are some major muscles of the thoracic and abdominal regions:

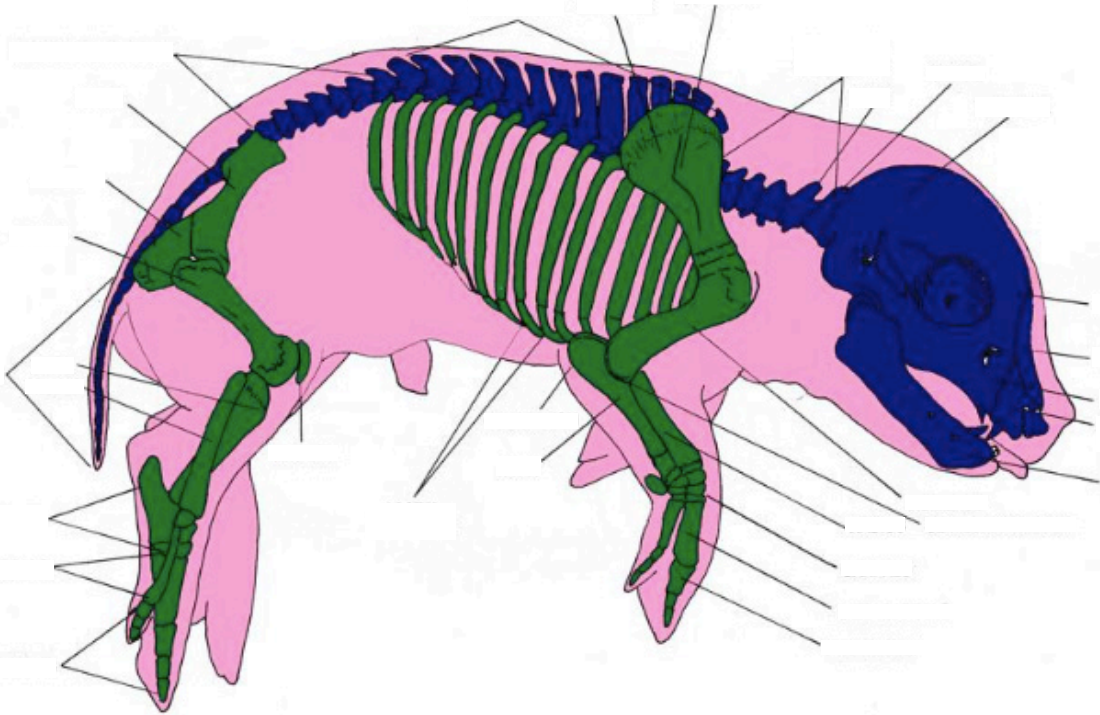
- *Brachiocephalic*: moves the forelimb in an anterior direction
- *Pectoralis major*: adducts, or moves the forelimb toward the chest
- *Pectoralis minor*: deep to Pectoralis major, moves forelimb toward and away from chest
- *Triceps*: moves forelimb in posterior direction
- *Serratus ventralis*: raises the rib cage during inhalation
- *Obliquus externus*: contracts and twists abdomen
- *Rectus abdominus*: contracts and twists abdomen

Major Bones of Fetal Pig Skeleton (teacher copy)

Ask the students to label the major bones in the fetal pig skeleton. They can either do this as a learning exercise using the 3D Pig Anatomy app or as a post-learning evaluation. There is a blank diagram on the next page to print and use.

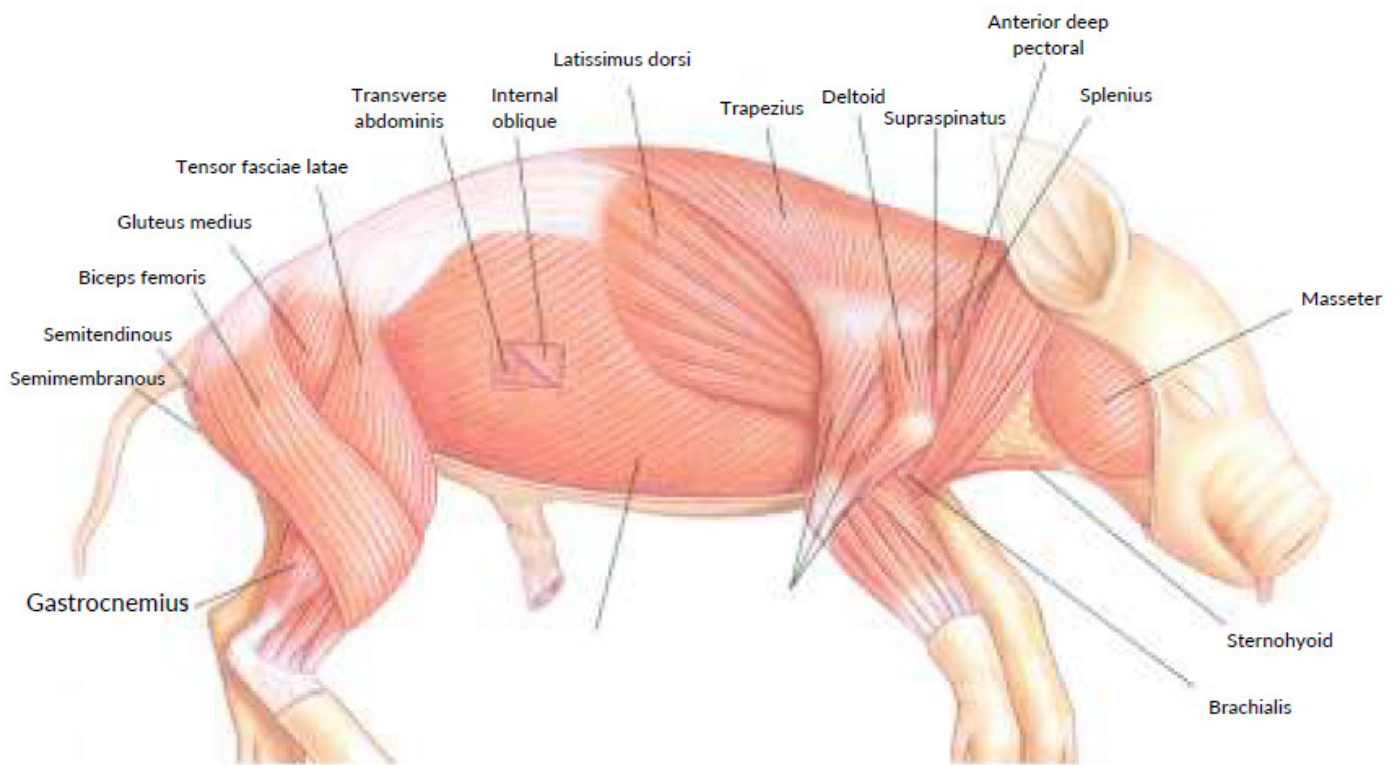


Major Bones of Fetal Pig Skeleton

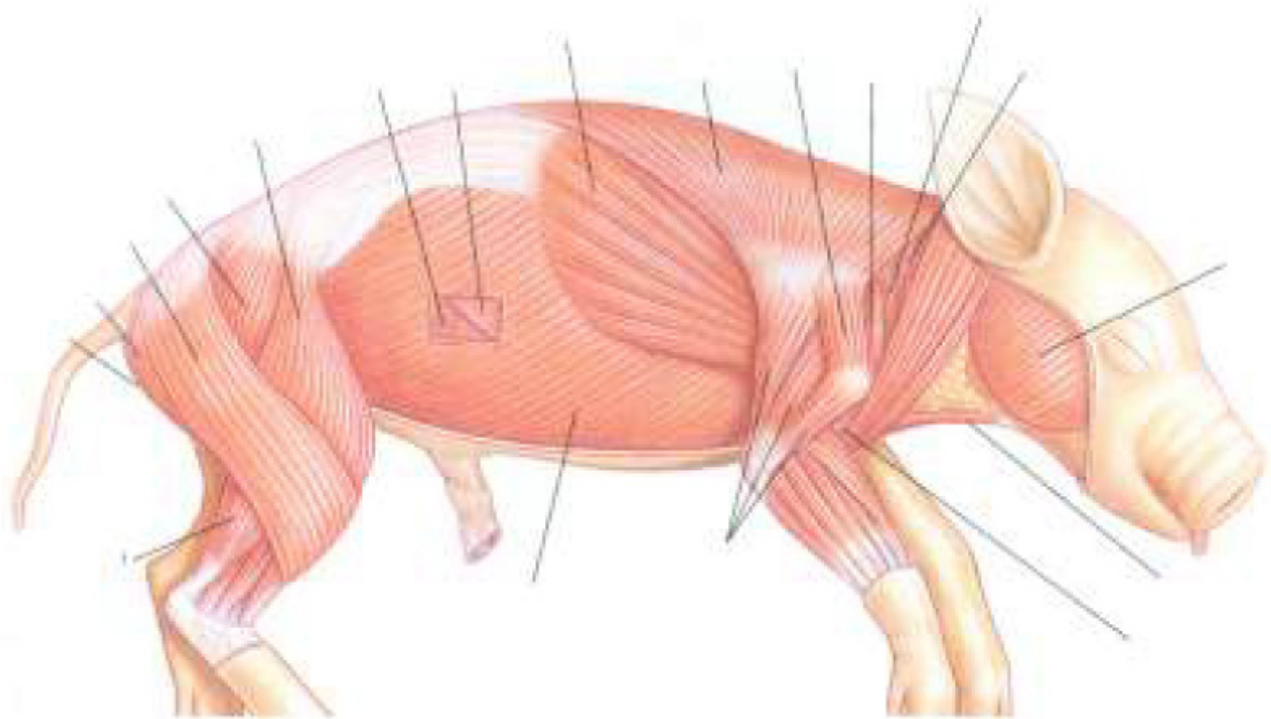


Major Muscles of Fetal Pig (teacher copy)

Ask the students to label the major muscles of the fetal pig. They can either do this as a learning exercise using the 3D Pig Anatomy app or as a post-learning evaluation. There is a blank diagram on the next page to print and use.



Major Muscles of Fetal Pig



Bone Types, Function, and Anatomy

TYPES OF BONES:

Long bones: These are mostly compacted bone with little marrow and include most of the bones in the limbs. These bones tend to support weight and help movement.

Short bones: Only a thin layer of compact bone, these include bones of the wrist and ankle.

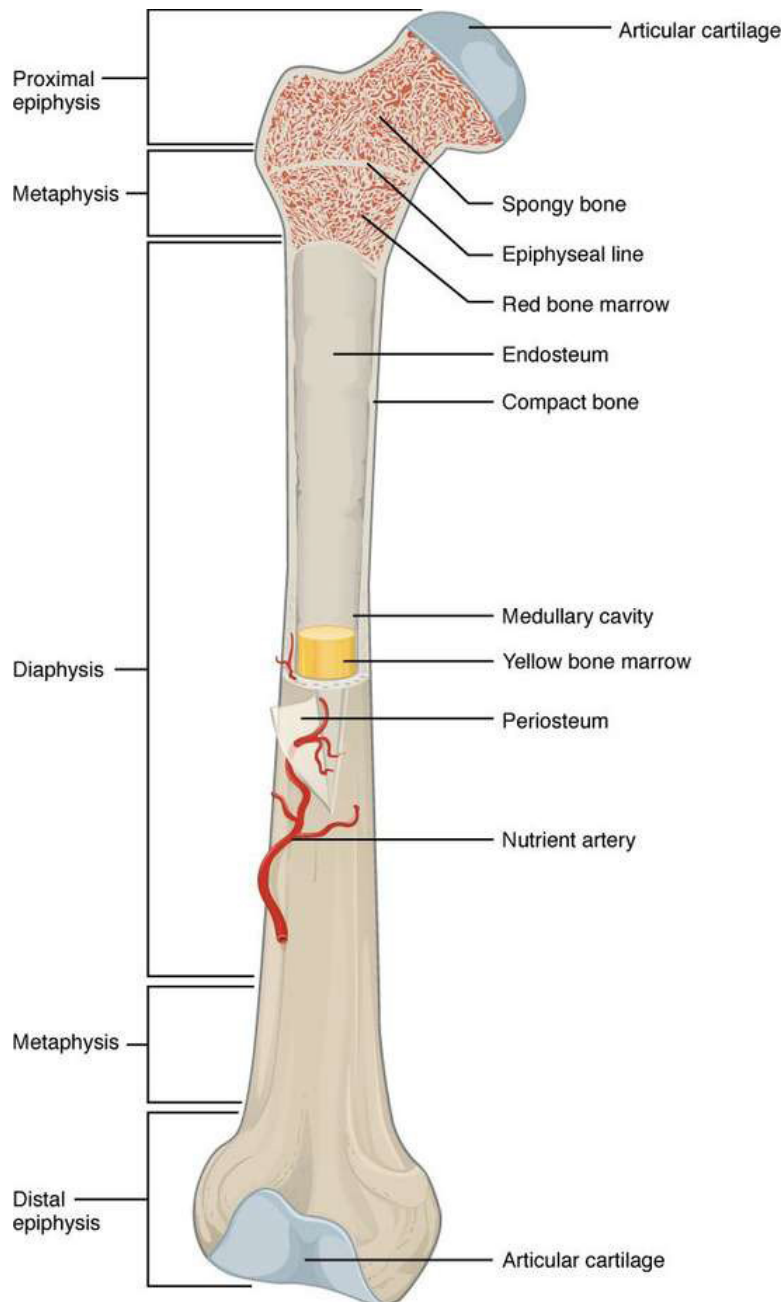
Flat bones: Usually bones that are thin and curved. They consist of two outer layers of compact bone and an inner layer of spongy bone. Flat bones include most of the bones of the skull and the sternum or breastbone. They tend to have a protective role.

Sesamoid bones: These are embedded in tendons, such as the patella or kneecap. They protect tendons from wear and stress.

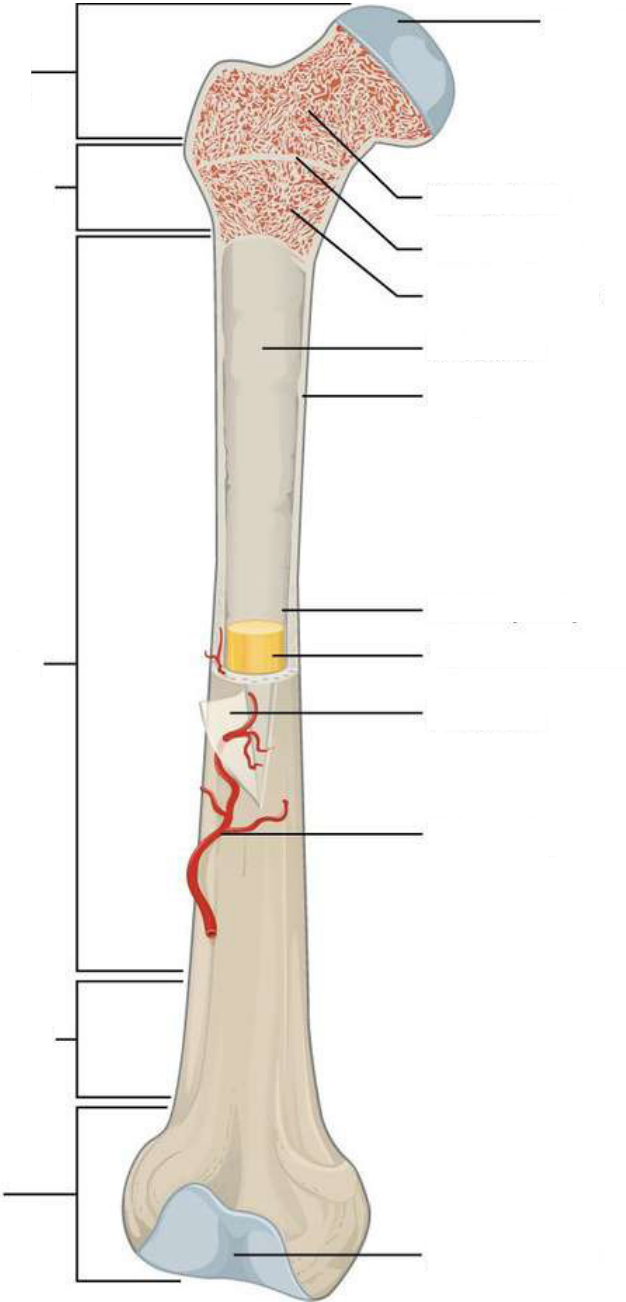
Irregular bones: As their name implies, these are bones that do not fit into the first four categories and are an unusual shape. They include the bones of the spine and pelvis. They are often protecting organs or tissues.

Long Bone Anatomy (teacher copy)

Ask the students to label the major components of long bones. They can either do this as a learning exercise or as a post-learning evaluation. There's a blank diagram on the next page to print and use.



Long Bone Anatomy



Muscle Types, Function, and Anatomy

TYPES OF MUSCLE:

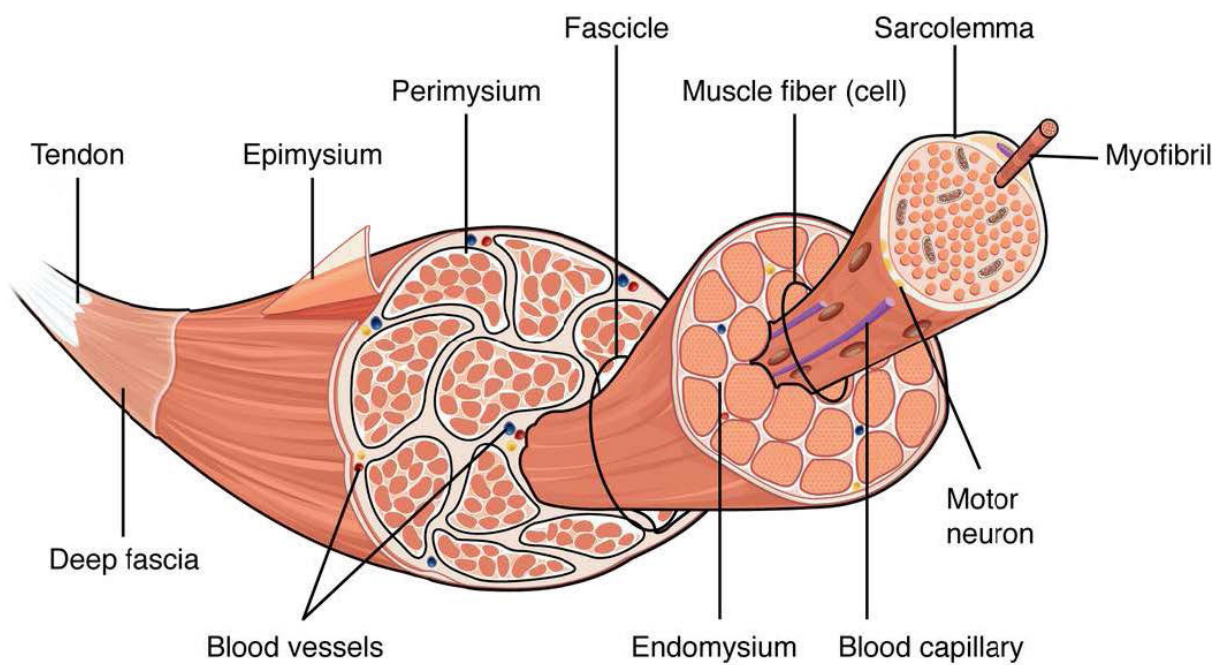
Skeletal muscle: Skeletal muscle, attached to bones, is responsible for skeletal movements. The peripheral portion of the central nervous system (CNS) controls the skeletal muscles. Thus, these muscles are under conscious, or voluntary, control. The basic unit is the muscle fibre with many nuclei. These muscle fibres are striated (having transverse streaks) and each acts independently of neighbouring muscle fibres.

Smooth muscle: Smooth muscle, found in the walls of the hollow internal organs such as blood vessels, the gastrointestinal tract, bladder, and uterus, is under control of the autonomic nervous system. Smooth muscle cannot be controlled consciously and thus acts involuntarily. The non-striated (smooth) muscle cell is spindle-shaped and has one central nucleus. Smooth muscle contracts slowly and rhythmically.

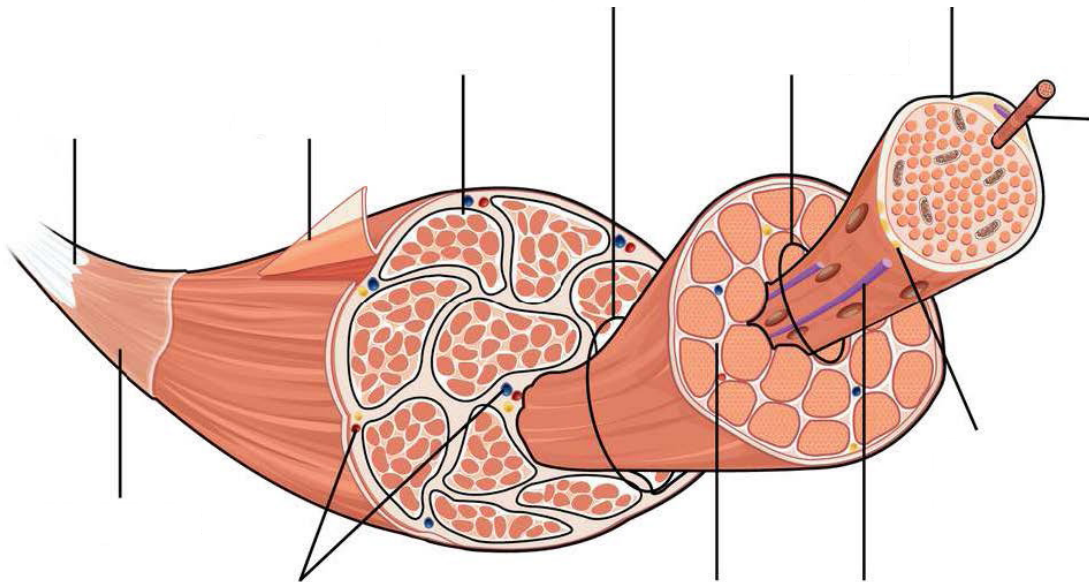
Cardiac muscle: Cardiac muscle, found in the walls of the heart, is also under control of the autonomic nervous system. The cardiac muscle cell has one central nucleus, like smooth muscle, but it also is striated, like skeletal muscle. The cardiac muscle cell is rectangular in shape. The contraction of cardiac muscle is involuntary, strong, and rhythmical.

Skeletal Muscle Anatomy (teacher copy)

Ask the students to label the major components of skeletal muscles. They can either do this as a learning exercise or as a post-learning evaluation. There's a blank diagram on the next page to print and use.



Skeletal Muscle Anatomy



Lesson 3: Respiratory System

TOPIC: Organ systems have complex interrelationships to maintain homeostasis. Homeostasis is maintained through physiological processes.

CONTENT: The pig respiratory system.

Goals	Students will be able to: <ul style="list-style-type: none">• Identify the major organs of the pig respiratory system• Explain the function and structure of each organ/tissue• Explain how the major organs in the respiratory system work together to maintain homeostasis• Explain how the respiratory system interacts with other organ systems
Objectives	After this lesson students will describe the structure and function of each organ/tissue in the respiratory system. They will also explain how the respiratory system maintains homeostasis, and explain key similarities and differences between pigs and humans.
Materials	<ul style="list-style-type: none">• 3D Pig Anatomy app by Biosphera• Pig Anatomy Workbook (to accompany 3D Pig Anatomy app)• Paper pig dissection by Getting Nerdy with Mel and Gerdy• Various anatomy worksheets (found within this document)
Introduction	Using the 3D Pig Anatomy app and the paper pig dissections, the teacher will introduce the respiratory system.
Development	Questions to support inquiry-based learning: <ul style="list-style-type: none">• How do the respiratory and circulatory systems interact with one another?• How do the respiratory organs/tissues help maintain homeostasis?• How does the respiratory system maintain internal balance during exercise?• What is the advantage of having specialized respiratory tissues?
Practice	Going one respiratory organ/tissue at a time, students will work independently or in pairs to fill out the legend of their paper pig dissection by using the 3D Pig Anatomy app to help them identify the different organs/tissues.

Respiratory System

Trachea	A cartilaginous tube that connects the larynx to the bronchi of the lungs, allowing the passage of air.
Bronchial tubes (bronchi)	Divides further into smaller branches called bronchioles.
Bronchioles	Small branched tubes that carry air to terminal air sacs called alveoli.
Alveoli	Air sacs that are located at the end of the bronchioles. Just one cell wall thick, the alveoli are surrounded by tiny blood vessels called capillaries, so they are the site of gas exchange in the lungs (i.e. where oxygen passes into the bloodstream, and carbon dioxide passes out).
Lungs	Major respiratory organs that expand and fill with air on an inhale, and deflate and empty of air on an exhale. 3 lobes on left, 4 on right.
Diaphragm	Major breathing muscle. Contracts and pulls down on an inhale causing air to rush into the lungs (negative pressure space). Relaxes and moves up on an exhale pushing air out of the lungs against the negative pressure gradient.

During check in:

Highlight key similarities between pigs and other species, especially humans:

The same major organs (trachea, bronchi, bronchioles, alveoli = lungs, and diaphragm)

Highlight key differences between pigs and other species, especially humans:

Pigs have different arrangement of lobes in their lungs (although same overall total lobes as humans)—three on the left, four on the right (humans have two on left, three on right).

Development question:

- How does the respiratory system interact with the circulatory system?
- What is the advantage of having specialized respiratory tissue?
- How does the respiratory system help maintain homeostasis?

Respiratory System

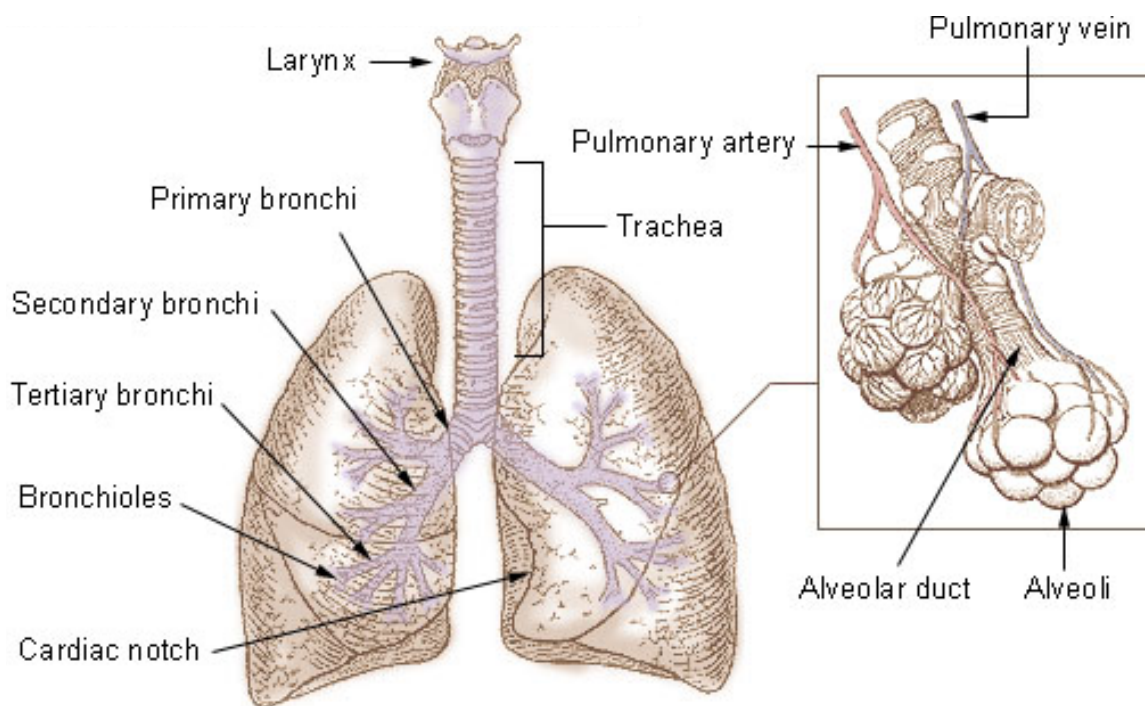
If the purpose of the heart is to move blood around the body, then the purpose of the respiratory system is to make that blood useful by removing waste products like CO₂ from the blood and supplying it with O₂. This begins with the process of inhalation and exhalation.

When an organism inhales, air containing oxygen and other trace elements is pulled in through the **nares** and **mouth** using contractions of the muscular **diaphragm**. The air travels through the **glottis** and down a cartilage-ringed tube called the **trachea**. Along the way, air gets passed over the **larynx**, or voice box, which resides on the anterior surface of the trachea and gives the pig the ability to make sounds for communication, etc. The trachea is divided into two branches called **bronchi** (singular: **bronchus**). Each bronchus carries air to a **lung**, the main structure responsible for gas exchange. Inside each lung, each bronchus is further divided into smaller tubes called **bronchioles**. The bronchioles terminate, or end, in small sac-like structures called **alveoli** (singular: **alveolus**). It is in the alveoli that gas exchange occurs. Each alveolus is wrapped in a network of capillaries from the pulmonary arteries and veins.

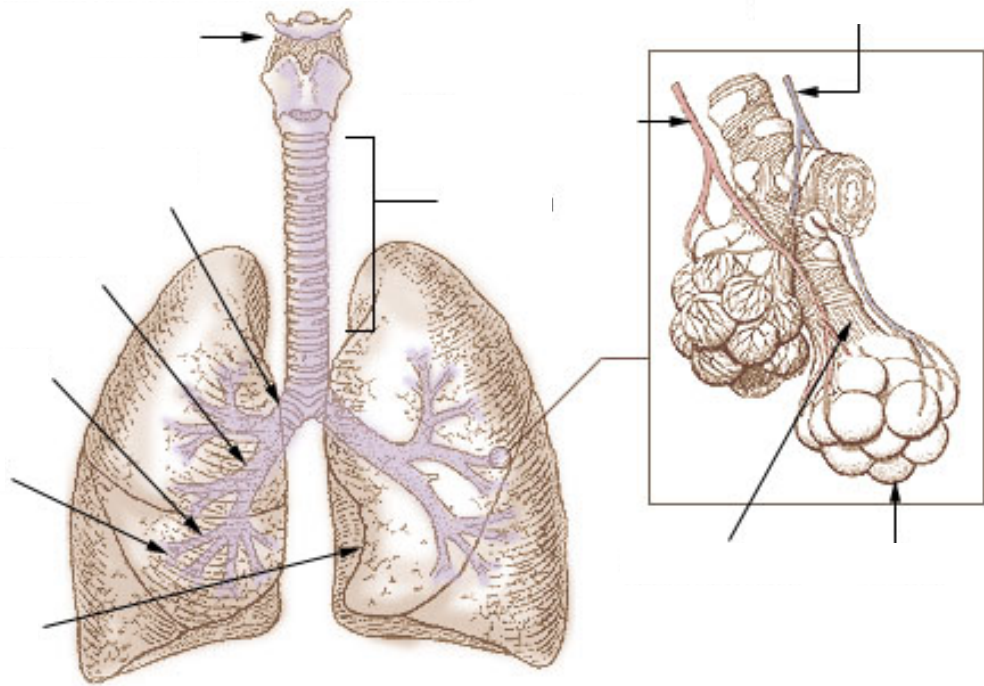
Blood cells in the pulmonary veins drop off carbon dioxide waste that is released from body cells to be exhaled by the lungs in the next breath. The blood cells in the pulmonary arteries pick up the inhaled oxygen that diffuses across the alveolar cells and carries it back to the heart to be pumped out to the rest of the body.

Respiratory System Anatomy (teacher copy)

Ask the students to label the major organs and tissues of the respiratory system. They can either do this as a learning exercise using the 3D Pig Anatomy app or as a post-learning evaluation. There's a blank diagram on the next page to print and use.

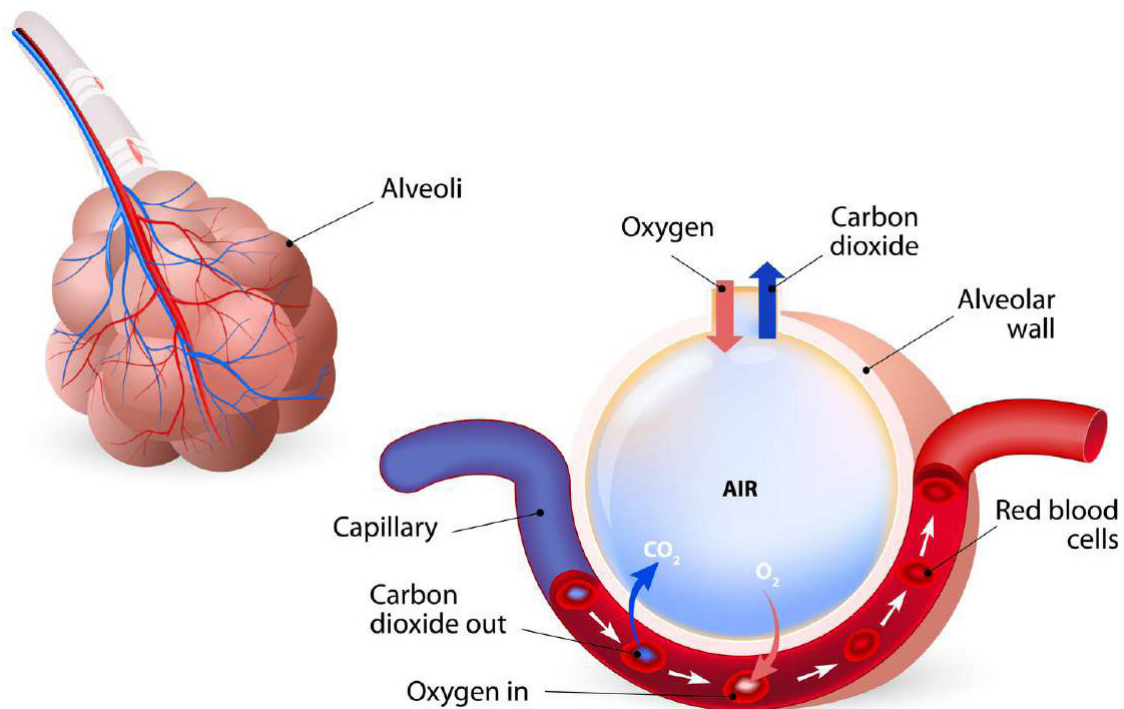


Respiratory System Anatomy

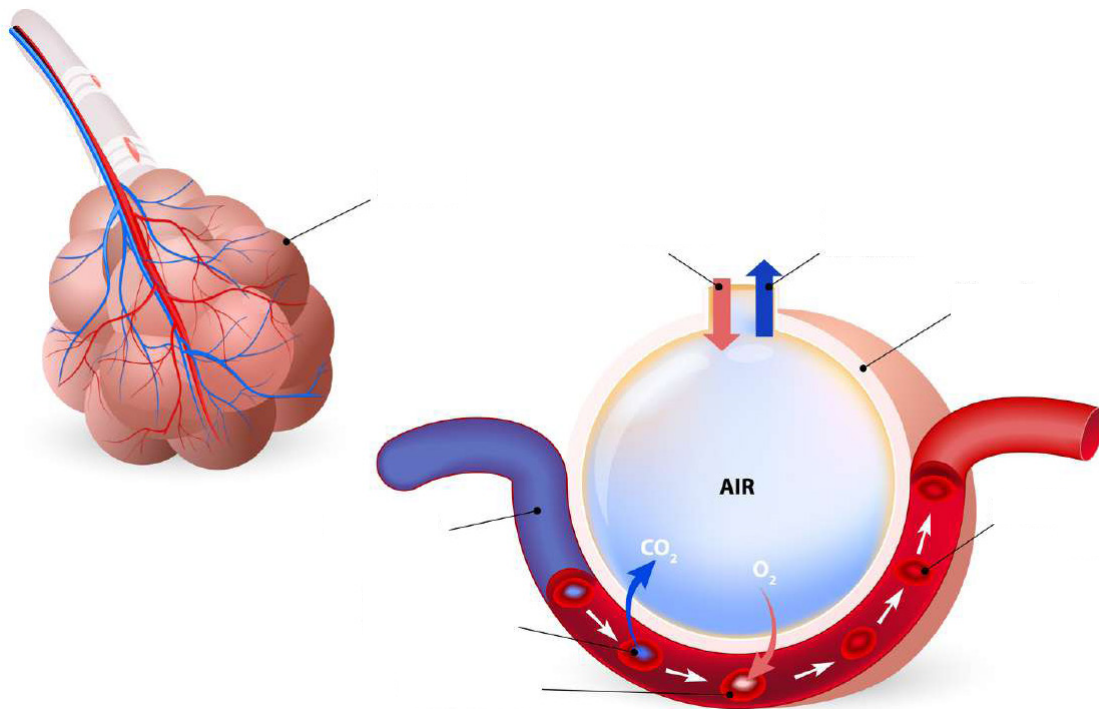


Gas Exchange (teacher copy)

Ask the students to label the diagram demonstrating gas exchange in the lungs, and how the respiratory and circulatory systems work together. They can either do this as a learning exercise or as a post-learning evaluation. There's a blank diagram on the next page to print and use.



Gas Exchange



Lesson 4: Circulatory System

TOPIC: Organ systems have complex interrelationships to maintain homeostasis. Homeostasis is maintained through physiological processes.

CONTENT: The pig circulatory system.

Goals	Students will be able to: <ul style="list-style-type: none">• Identify the major organs of the pig circulatory system• Explain the function and structure of each organ• Explain how the major organs in the circulatory system work together to maintain homeostasis• Explain how the circulatory system interacts with other organ systems
Objectives	After this lesson students will describe the structure and function of each organ in the circulatory system. They will also explain how the circulatory system maintains homeostasis, and explain key similarities and differences between pigs and humans.
Materials	<ul style="list-style-type: none">• 3D Pig Anatomy app by Biosphera• Pig Anatomy Workbook (to accompany 3D Pig Anatomy app)• Paper pig dissection by Getting Nerdy with Mel and Gerdy• Various anatomy worksheets (found within this document)
Introduction	Using the 3D Pig Anatomy app and the paper pig dissections, the teacher will introduce the circulatory system.
Development	Questions to support inquiry-based learning: <ul style="list-style-type: none">• How do the circulatory and respiratory/digestive systems interact with one another?• How do the circulatory organs help maintain homeostasis?• How does the circulatory system maintain internal balance during exercise?• What is the advantage of having specialized circulatory tissues?
Practice	Going one circulatory organ at a time, students will work independently or in pairs to fill out the legend of their paper pig dissection by using the 3D Pig Anatomy app to help them identify the different organs.

Circulatory System

Heart	<p>Like humans, pigs have four heart chambers: two atria, two ventricles.</p> <ul style="list-style-type: none">• Blood from the posterior portion of the body enters the right atrium of the heart through the inferior vena cava and the superior vena cava.• Blood flows from the right atrium to the right ventricle via the tricuspid valve.• Blood is then pumped through the pulmonary semilunar valve and into the pulmonary trunk where blood travels to the lungs.• Blood then flows through the pulmonary arteries to the lungs where it is oxygenated and then returns from the lungs to enter the left atrium via four pulmonary veins.• Blood goes from the left atrium to the left ventricle via the bicuspid (or mitral) valve.• Blood leaves the left ventricle of the heart through the aortic semilunar valve and enters the aorta, where it is then distributed to the rest of the body.
Veins	<p>Veins ALWAYS carry blood towards the heart, and usually carry deoxygenated blood. The only vein that carries oxygenated blood is the pulmonary vein which carries blood from the lungs towards the heart. Major vein = vena cava.</p>
Bronchioles	<p>Arteries ALWAYS carry blood away from the heart, and usually carry oxygenated blood. The only vein that carries deoxygenated blood is the pulmonary artery that carries deoxygenated blood away from the heart to the lungs. Major artery = aorta.</p>
Capillaries	<p>Capillaries are tiny blood vessels that are just one cell wall thick. This means that various substances like gases, nutrients, waste products, hormones etc can pass across the cell wall of capillaries.</p>
Aorta	<p>Major artery that receives blood straight from the heart. Four aortic regions: 1) ascending aorta—the upper part of the vessel that starts at the atrium, 2) aortic arch—the place where the aorta bends to the left, 3) descending aorta—after the bend the aorta can be traced toward the diaphragm, 4) abdominal aorta—the aorta passes through the diaphragm and supplies blood to the lower extremities.</p>

During check in:

Highlight key similarities between pigs and other species, especially humans:

The same major organs (heart, veins, arteries, capillaries)

Highlight key differences between pigs and other species, especially humans:

No major differences

Development question:

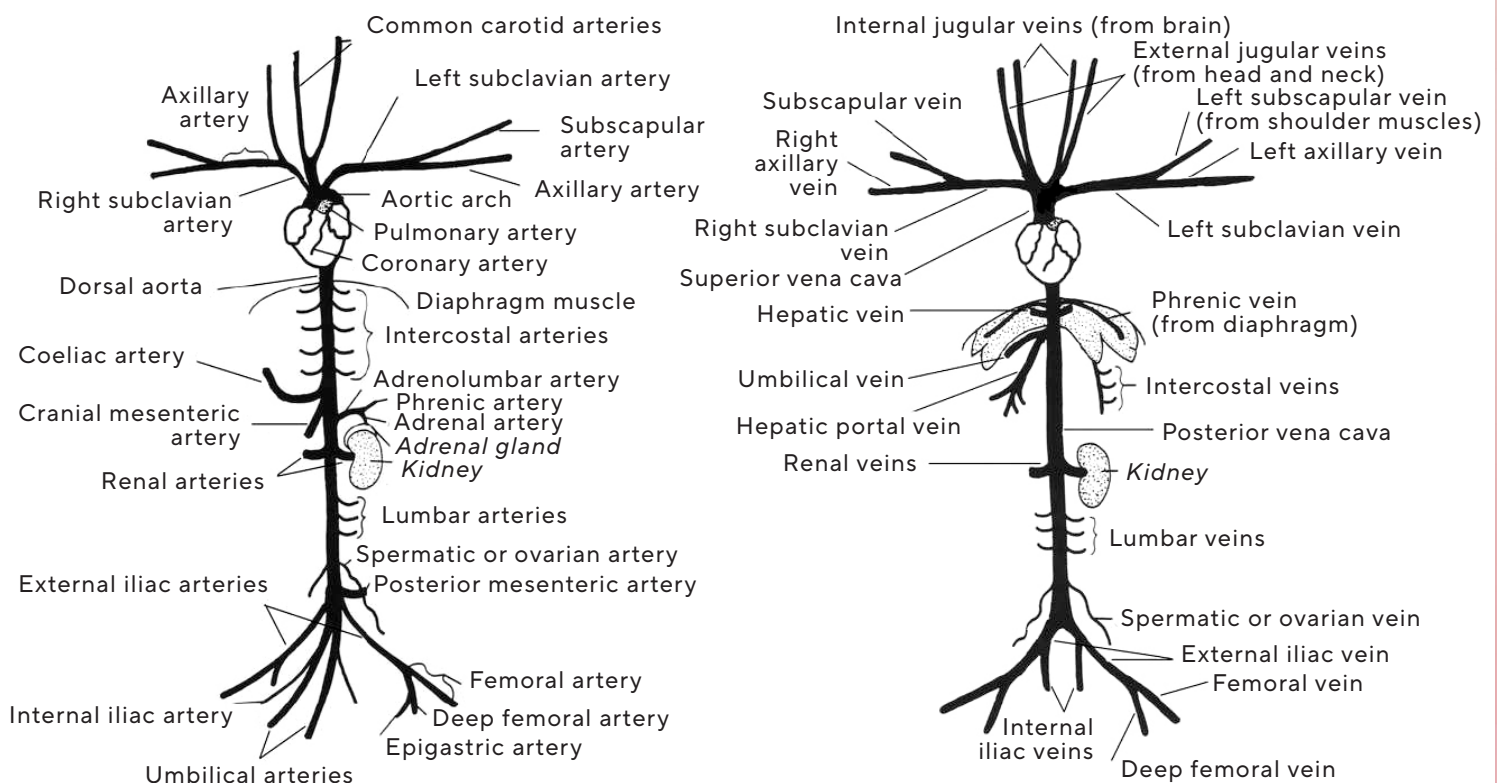
- How does the circulatory system interact with other organ systems?
- What is the advantage of having specialized circulatory tissue?
- How does the circulatory system help maintain homeostasis?

Circulatory System

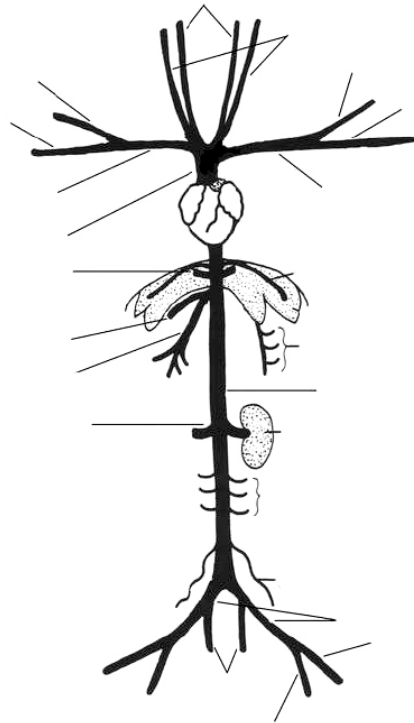
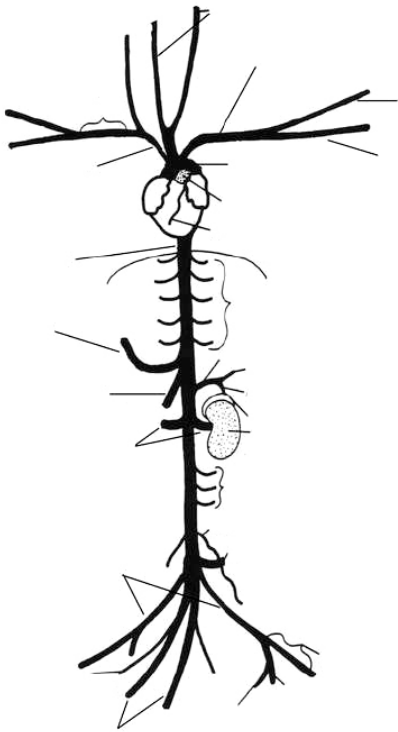
<p>Tracing the branches of the aortic arch</p>	<ol style="list-style-type: none"> 1. Coronary arteries are located on top of the heart and supply the heart itself with blood. 2. The first visible branch from the aorta is the brachiocephalic artery, it divides into the right common carotid artery, which supplies the right side of the neck, and the right subclavian artery, which supplies the right shoulder and fore limbs. 3. At the most anterior part of the bend in the aortic arch is the left common carotid artery, which supplies blood up the left side of the neck. The common carotid artery branches into the internal and external carotid. 4. Immediately to the left of the left common carotid artery is the left subclavian artery, which supplies blood to the left shoulder and fore limb. The subclavian artery becomes the axillary artery as it enters the fore limb.
<p>Tracing the branches of the abdominal aorta</p>	<ol style="list-style-type: none"> 1. The first arterial branch from the abdominal aorta (below the diaphragm) is the celiac artery, which branches to arteries that supply the stomach (gastric artery), liver (hepatic artery), spleen and pancreas (splenic artery). 2. The second artery arising from the abdominal artery is the superior mesenteric artery, which is larger than the celiac, and delivers blood directly to the small intestine. 3. The renal arteries are short and lead directly to the kidneys. 4. Just posterior to the renal arteries are the genital arteries, which lead to the testes or the ovaries. 5. Farther along the abdominal aorta, you can find the iliolumbar arteries which lead to the dorsal muscles of the back. 6. Next, the inferior mesenteric artery leads to the intestinal mesenteries. 7. The abdominal aorta gives rise to the caudal artery, which goes on into the tail. 8. The abdominal aorta finally divides to form the iliac arteries, which deliver blood to the pelvis and hind legs. 9. The iliac arteries lead to the femoral artery in the hind leg.
<p>Tracing the branches of the systemic veins</p>	<ol style="list-style-type: none"> 1. The left and right superior vena cava conduct blood from the upper part of the body into the right atrium. Trace these veins from the atrium until you find the small internal jugular vein, and continues as the subclavian vein. 2. The subclavian vein divides into the external jugular vein and the axillary vein. 3. The inferior vena cava carries blood from the lower part of the body to the right atrium. The hepatic vein drains the liver and enters the inferior vena cava near the diaphragm. 4. Renal veins drain the kidneys. 5. Genital veins lead from the gonads and enter the inferior vena cava. 6. The iliac and femoral veins drain the hind legs. 7. The caudal vein drains the tail.

Major Thoracic and Abdominal Arteries and Veins of the Fetal Pig (teacher copy)

Ask the students to label the major blood vessels of the pig. They can either do this as a learning exercise using the 3D Pig Anatomy app or as a post-learning evaluation. There's a blank diagram on the next page to print and use.

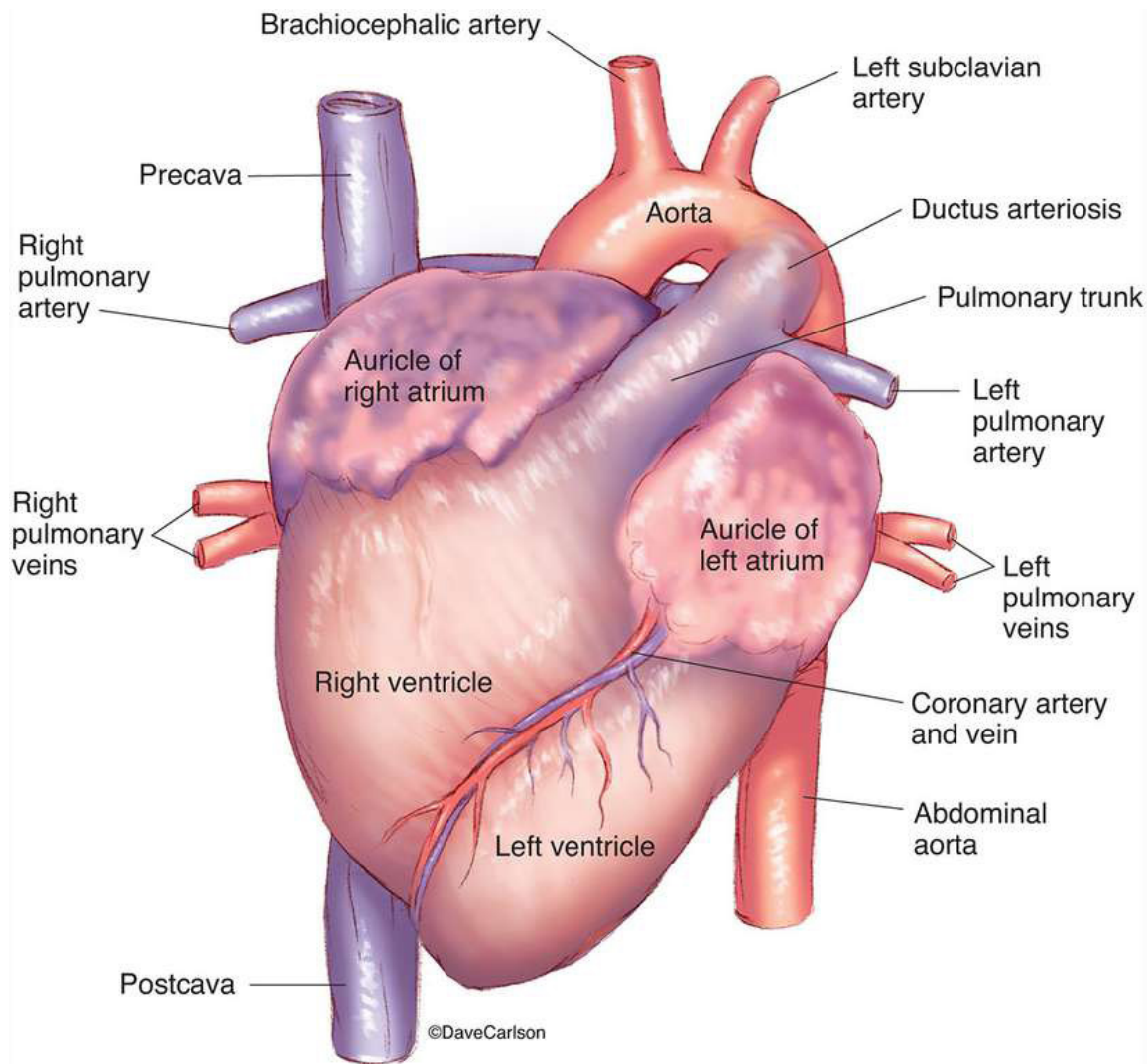


Major Thoracic and Abdominal Arteries and Veins of the Fetal Pig

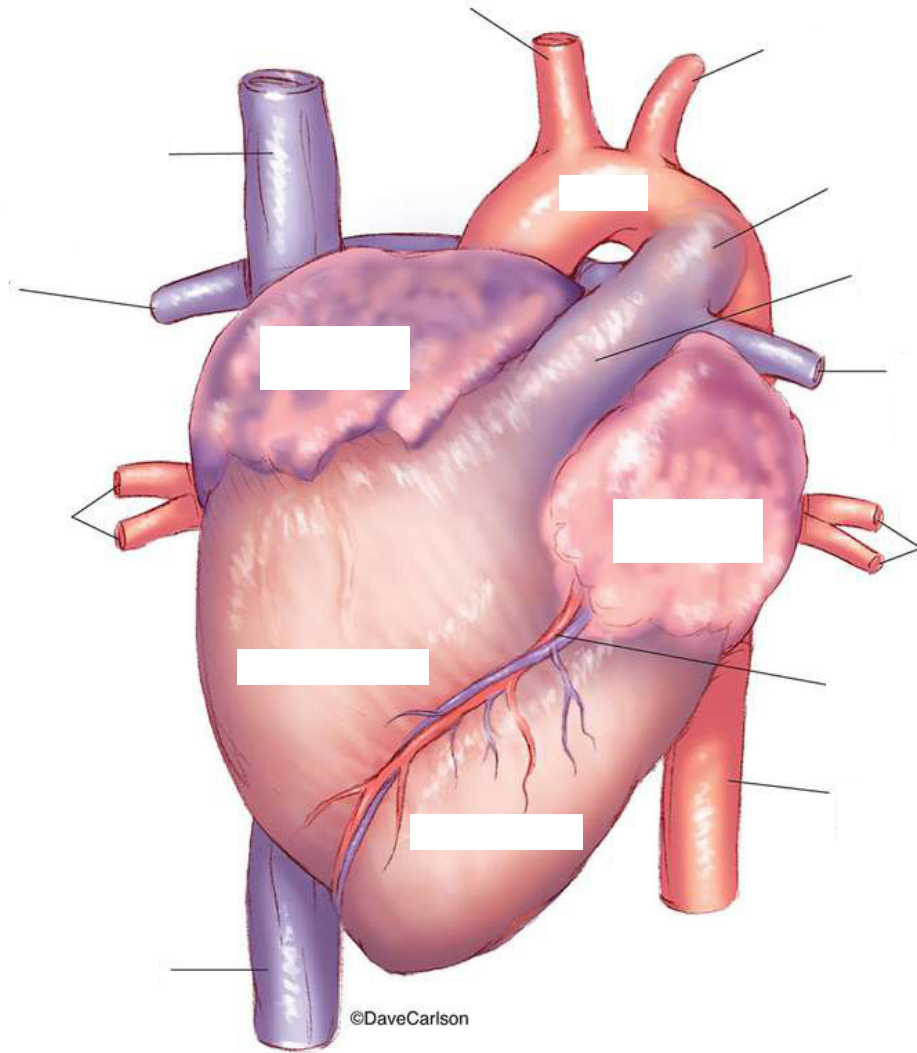


Fetal Pig Heart Anatomy (teacher copy)

Ask the students to label the heart chambers of the pig. They can either do this as a learning exercise using the 3D Pig Anatomy app or as a post-learning evaluation. There's a blank diagram on the next page to print and use.



Fetal Pig Heart Anatomy



Lesson 5: Digestive System

TOPIC: Organ systems have complex interrelationships to maintain homeostasis. Homeostasis is maintained through physiological processes.

CONTENT: The pig digestive system.

Goals	Students will be able to: <ul style="list-style-type: none">• Identify the major organs of the pig digestive system• Explain the function and structure of each organ• Explain how the major organs in the digestive system work together to maintain homeostasis• Explain how the digestive system interacts with other organ systems
Objectives	After this lesson students will describe the structure and function of each organ in the digestive system. They will also explain how the digestive system maintains homeostasis, and explain key similarities and differences between pigs and humans.
Materials	<ul style="list-style-type: none">• 3D Pig Anatomy app by Biosphera• Pig Anatomy Workbook (to accompany 3D Pig Anatomy app)• Paper pig dissection by Getting Nerdy with Mel and Gerdy• Various anatomy worksheets (found within this document)
Introduction	Using the 3D Pig Anatomy app and the paper pig dissections, the teacher will introduce the various organ systems.
Development	Questions to support inquiry-based learning: <ul style="list-style-type: none">• How do the digestive and circulatory systems interact with one another?• How do the digestive organs help maintain homeostasis?• How does the digestive system maintain internal balance during exercise?• What is the advantage of having specialized digestive tissues?
Practice	Going one digestive organ at a time, students will work independently or in pairs to fill out the legend of their paper pig dissection by using the 3D Pig Anatomy app to help them identify the different organs.

Digestive System

Mouth	Digestion begins in the mouth. Parotid glands produce saliva, which breaks down carbohydrates.
Esophagus	After swallowing food moves through the esophagus. Wave-like muscular contractions along the esophagus, called peristalsis, move the food along, through the esophageal sphincter and into the stomach.
Stomach	The stomach uses mechanical and chemical digestion to break down food further. Three layers of muscle (longitudinal, circular, oblique muscles) contract in different directions to break down food mechanically. Gastric acid (hydrochloric acid) and protein-digesting enzymes are released into the stomach for chemical digestion. Different sections of the stomach = cardiac region, fundus, body and pylorus.
Small Intestine	Food then passes into the small intestine via the pyloric sphincter. In the upper portion of the small intestine (the duodenum) digestion continues via secretion of pancreatic digestive enzymes from the pancreas (via the pancreatic duct), and bile from the gallbladder (via the bile duct). In the lower portions of the small intestine (the jejunum and ileum), nutrient absorption occurs via intestinal villi which line the inner surface of the intestine. Nutrients pass across the villi wall to surrounding capillaries and into the bloodstream.
Pancreas	Both a digestive and endocrine organ. In its digestive function it releases digestive enzymes into the small intestine that break down carbohydrates and proteins. In its endocrine function it produces insulin, glucagon and glycogen, which together work to regulate blood sugar levels.
Liver	Has 5 lobes. Produces bile which contains enzymes that break down fats. Also the body's major waste filter—via the hepatic portal system blood is filtered through special functional cells called hepatocytes.
Gallbladder	Stores bile and releases it into duodenum via bile duct.
Large intestine	Regions = Caecum, ascending colon, transverse colon, descending colon, sigmoid colon, rectum. Primarily responsible for absorption of water.

During check in:

Highlight key similarities between pigs and other species, especially humans:
The same major organs (heart, veins, arteries, capillaries)

Highlight key differences between pigs and other species, especially humans:
No major differences

Development question:

- How do the digestive and circulatory systems interact with one another?
- How does the digestive system maintain internal balance during exercise?
- What is the advantage of having specialized digestive tissues?

Digestive System

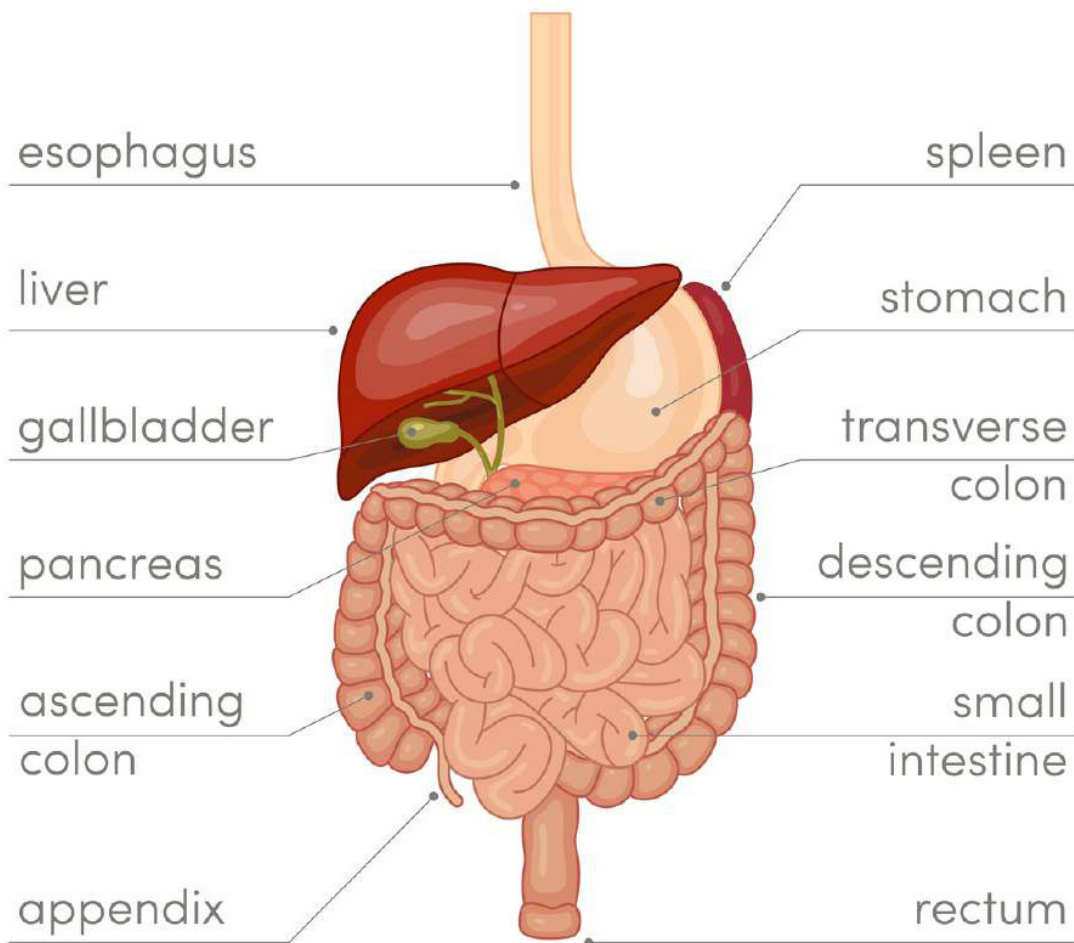
On the roof of the pig's mouth are two distinct regions. The **hard palate** is the ridged area located near the front of the mouth. It separates the oral cavity from the nasal cavity. Caudal, or behind the hard palate, is the **soft palate**. The muscular soft palate aids in swallowing. The common passage through which food and air travels is the **pharynx**. It is divided into three areas: the oropharynx, **nasopharynx**, and the laryngopharynx. The nasopharynx transports air inhaled through the nares to the oral cavity and then to the lungs. The large, muscular opening at the back of the throat is the **esophagus** which carries food from the mouth to the stomach. Adult domesticated pigs are omnivorous, meaning they eat both plant and animal material such as fruits, vegetables, and insects. They have four types of teeth: incisors, canines, premolars and molars. Incisors are used for clipping, gripping and/or ripping food while canines function in tearing and shredding food. Both the canines and incisors can be present in fetal pigs, as well as cheek teeth which are found near the back of the oral cavity. The muscular **tongue** found on the floor of the mouth is used in making sounds, chewing and to move food to the back of the mouth to be swallowed. At the posterior region of the tongue is the **epiglottis**, a small flap that covers the glottis, the opening to the respiratory system. The epiglottis prevents food or water from entering the trachea when the animal is breathing. Under the neck skin flap are two strong muscles on either side of the mouth called the **masseter muscles**. These are used to chew food. Anterior to those, the **mylohyoid muscle** is used to raise the floor of the mouth. A pair of **parotid glands** create saliva to help begin the digestive process in the oral cavity.

Food is transported to the pouch-like stomach via the **esophagus** using peristaltic contractions. Food undergoes mechanical and chemical digestion in the **stomach** until it is a mushy substance called chyme. It is stored in the stomach until it is ready to be released into the **small intestine**. The small intestine is divided into three main sections: the **duodenum** (beginning) which receives enzymes via ducts from the digestive glands, liver and pancreas, the **jejunum** (middle), and **ileum** (end). It is responsible for the chemical digestion of food and the absorption of nutrients through millions of tiny finger-like projections lining the small intestine called villi. It is wound tightly upon itself in the abdominal cavity with the help of the intestinal mesentery, a membrane that not only holds the intestines together, but also holds various blood vessels that supply nutrients to and from the intestines. At the junction of the small intestine and the large intestine is the **caecum**, a large pouch-like structure that houses bacteria necessary for the digestion of plant materials. The **large intestine** functions in the reabsorption of water out of the remaining undigested food before it is passed to the **rectum** to be stored until it is excreted from the body through the **anus**.

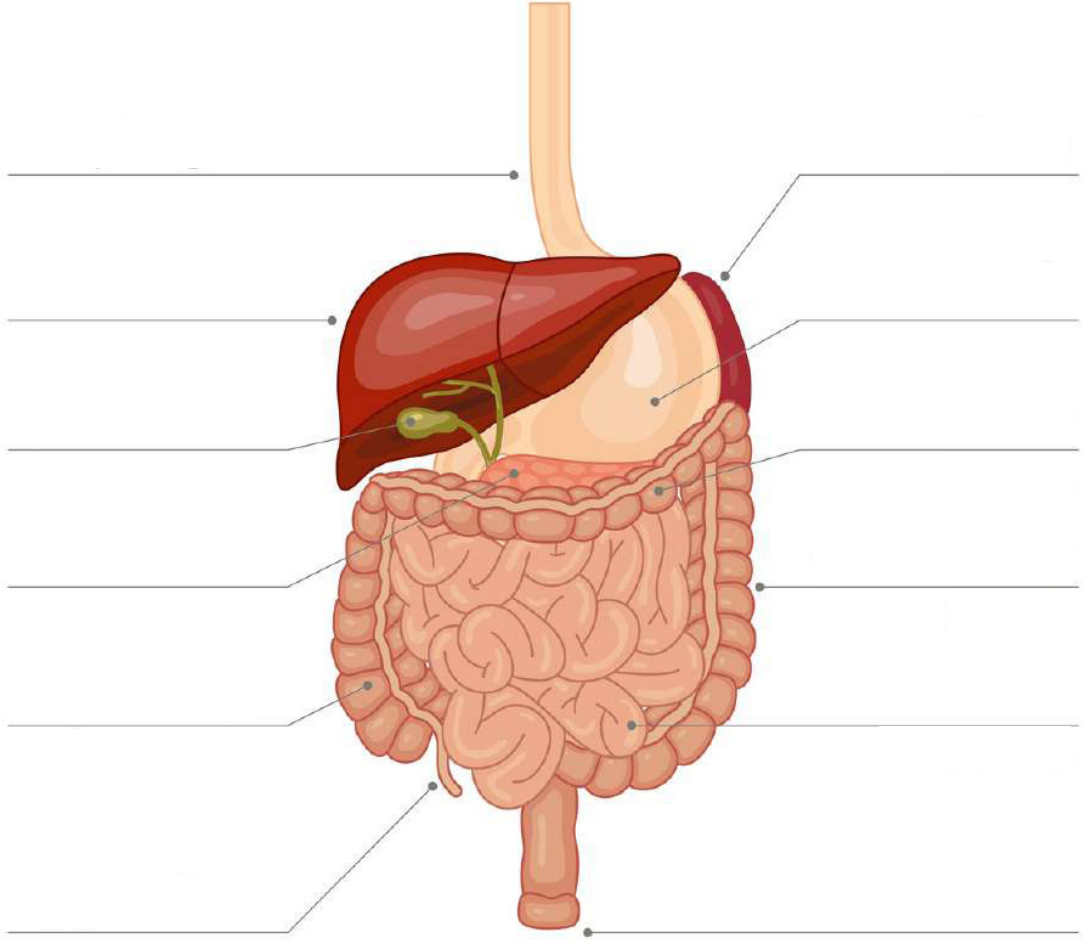
Accessory organs in the digestive system are necessary components of the digestive process. The **liver** serves as a filter for removing toxic substances from the blood, as well as functions in the creation of bile. **Bile** that is created in the liver is stored in the **gallbladder** and is transported there through the **common bile duct**. The bile is then secreted into the **duodenum** of the small intestine to aid in the break down of fat within the digestive tract. The granular looking **pancreas**, located below the stomach and duodenum, makes a variety of digestive enzymes, including insulin to regulate blood sugar as well as others that aid in breaking food down even further. The smooth **spleen** also located near the digestive organs, functions in the destruction of old red blood cells.

Digestive System Anatomy (teacher copy)

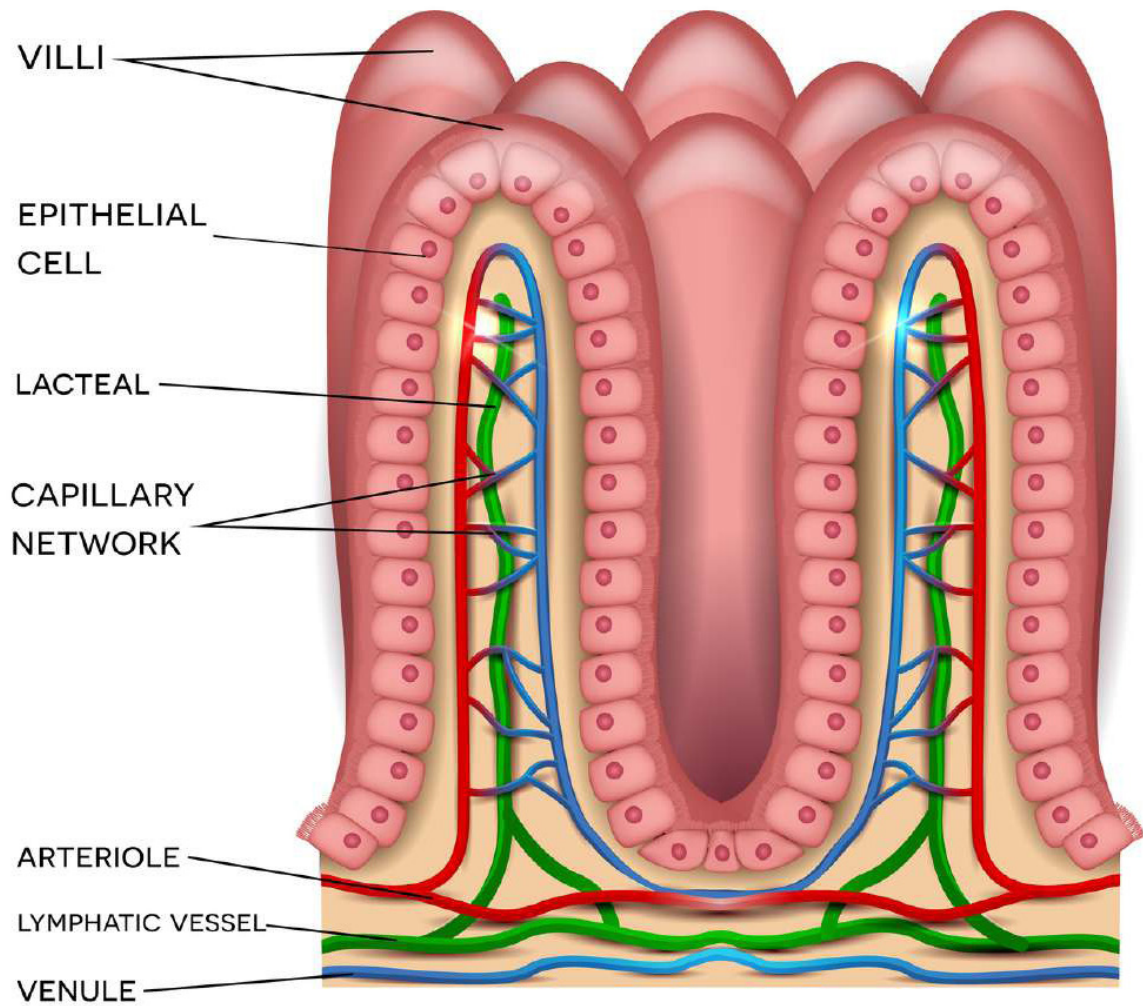
Ask the students to label the major parts of the pig digestive system. They can either do this as a learning exercise using the 3D Pig Anatomy app or as a post-learning evaluation. There's a blank diagram on the next page to print and use.



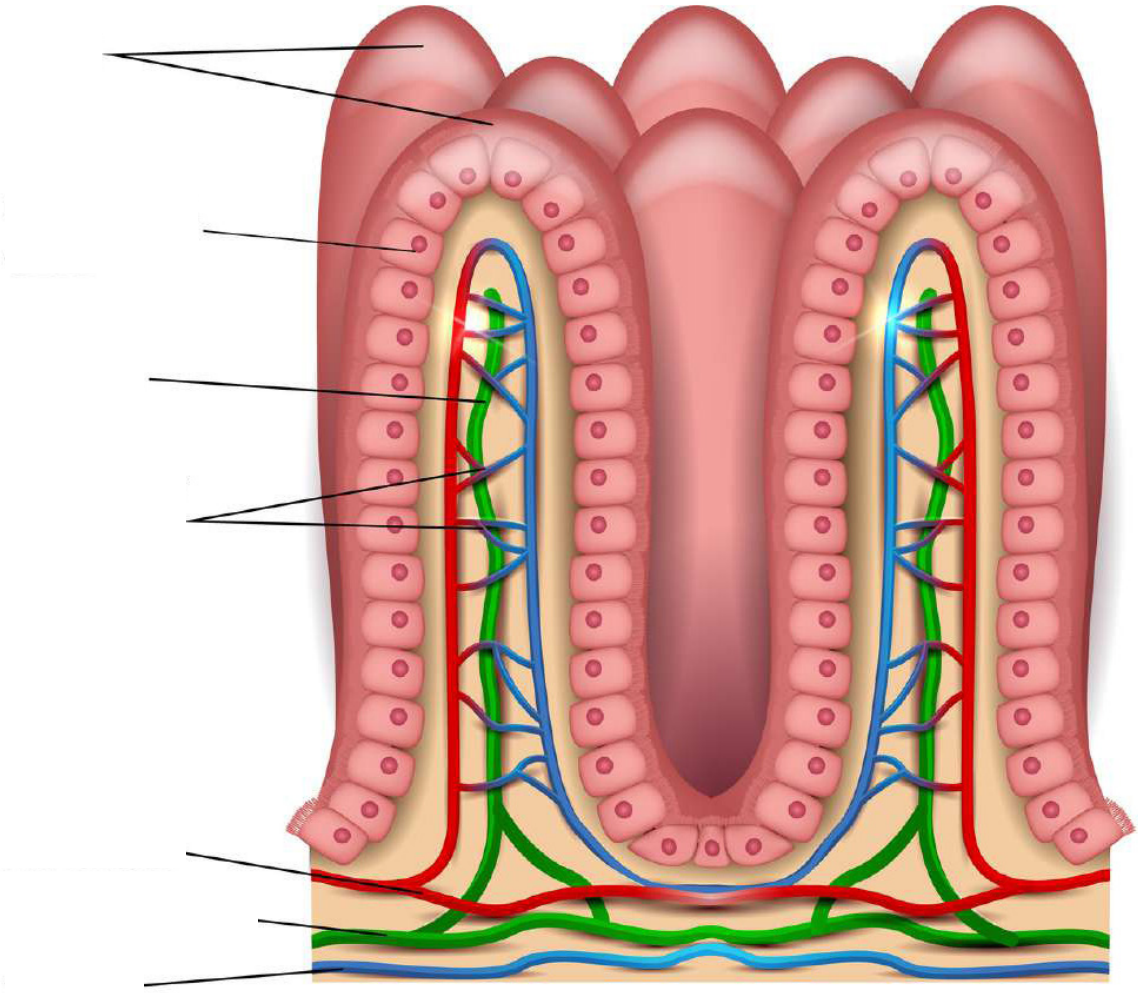
Digestive System Anatomy



Intestinal Villi Anatomy (teacher copy)



Intestinal Villi Anatomy



Lesson 6: Urogenital System

TOPIC: Organ systems have complex interrelationships to maintain homeostasis. Homeostasis is maintained through physiological processes.

CONTENT: The pig urogenital system.

Goals	Students will be able to: <ul style="list-style-type: none">• Identify the major organs of the pig urogenital system• Explain the function and structure of each organ• Explain how the major organs in the urogenital system work together to maintain homeostasis• Explain how the urogenital system interacts with other organ systems
Objectives	After this lesson students will describe the structure and function of each organ in the urogenital system. They will also explain how the urogenital system maintains homeostasis, and explain key similarities and differences between pigs and humans.
Materials	<ul style="list-style-type: none">• 3D Pig Anatomy app by Biosphera• Pig Anatomy Workbook (to accompany 3D Pig Anatomy app)• Paper pig dissection by Getting Nerdy with Mel and Gerdy• Various anatomy worksheets (found within this document)
Introduction	Using the 3D Pig Anatomy app and the paper pig dissections, the teacher will introduce the urogenital system.
Development	Questions to support inquiry-based learning: <ul style="list-style-type: none">• How do the urogenital and circulatory systems interact with one another?• How do the urogenital organs help maintain homeostasis?• How does the urogenital system maintain internal balance during exercise?• What is the advantage of having specialized urogenital tissues?
Practice	Going one urogenital organ at a time, students will work independently or in pairs to fill out the legend of their paper pig dissection by using the 3D Pig Anatomy app to help them identify the different organs.

Urogenital System

Kidneys	A pair of organs that filter blood and produce urine. Functional unit = nephrons, which are responsible for blood filtration, reabsorption of water and other important substances, and secretion of urine.
Ureters	A pair of tubes that connect the kidneys and bladder. The urine produced by the kidneys travels along these tubes for storage in the bladder.
Bladder	Stores urine.
Urethra	Urine travels along this tube to exit the body.
Testes	Pair of oval-shaped structures that produce sperm.
Epididymis	Stores sperm produced by the testes.
Vas deferens	Tube that sperm travels down to reach the penis.
Prostate, bulbourethral glands	Produce a fluid that nourishes and protects sperm.
Ovaries	Paired structures that produce eggs.
Oviducts	Ducts that connect the ovaries and uterus.
Uterus	Receives eggs and supports the development of growing embryos until birth. Pigs have a duplex uterus that consists of two separate uterine horns.
Vagina	Serves as a birth canal and also is the orifice that accepts sperm during mating.

During check in:

Highlight key similarities between pigs and other species, especially humans:
Same major urogenital system components.

Highlight key differences between pigs and other species, especially humans:
No major differences

Development question:

- How does the urogenital system interact with other organ systems?
- What is the advantage of having specialized urogenital tissue?
- How does the urogenital system help maintain homeostasis?

Urogenital System

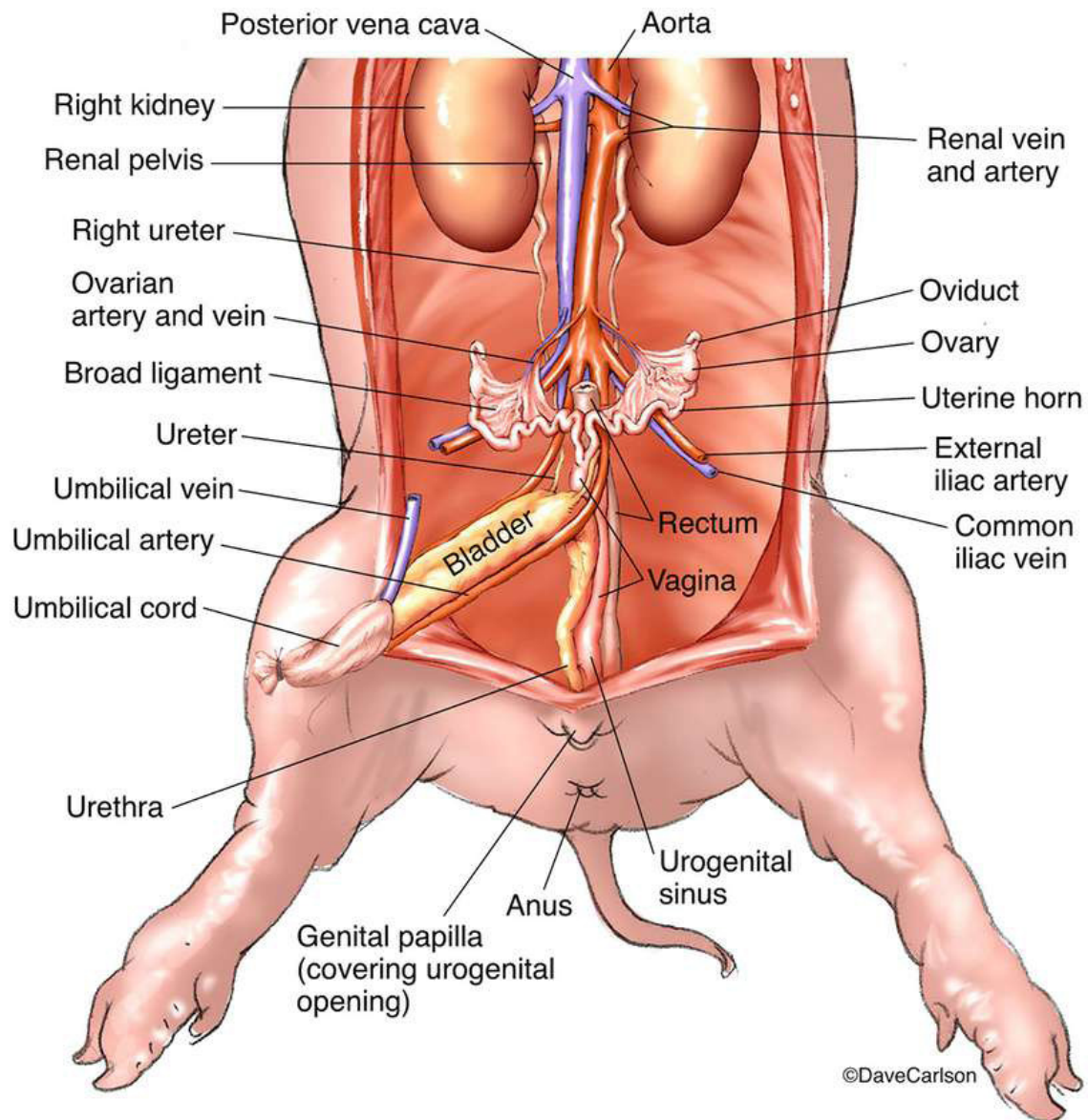
The urinary system provides the function of filtering the blood of wastes, excess fluids, and urea, and then eliminating them from the body. It does this using two bean-shaped **kidneys** located below the diaphragm along the dorsal side of the body. On top of each kidney sits a triangular-shaped **adrenal gland** responsible for dumping adrenaline into the blood stream when the pig encounters a “fight or flight” situation. Each kidney receives blood from the heart through the **renal artery** which branches from the descending aorta. The blood then travels inside the kidney through tiny structures called **nephrons** which filter the blood of waste. The waste is collected and then transported through two tubes called **ureters** which attach to a muscular sac called the **bladder**. The smooth muscle-lined bladder stores the urine and remains relaxed until it becomes full, at which point the brain signals the muscle cells to contract and release the contents through another tube called the **urethra**.

In male pigs, the urethra serves as both an exit for the urinary system as well as the reproductive system. This common exit is called the urogenital opening and is found at the tip of the reproductive structure in males, called a **penis**. In females, the urethra (anterior) and vaginal orifice (posterior) are separate but share a common location under the urogenital papilla, a flap of skin covering the genitalia of some mammals. The **testes**, which are housed in the scrotal sac once they descend out of the abdominal cavity, are responsible for making sperm. The **epididymis** collects the sperm and stores it until it is ready to be activated and released from the body. It then travels through the **vas deferens**, which connects the epididymis to the urethra. A **bulbourethral gland** located on either side of the penis adds seminal fluid to the ejaculate before it is released from the body through the urogenital opening.

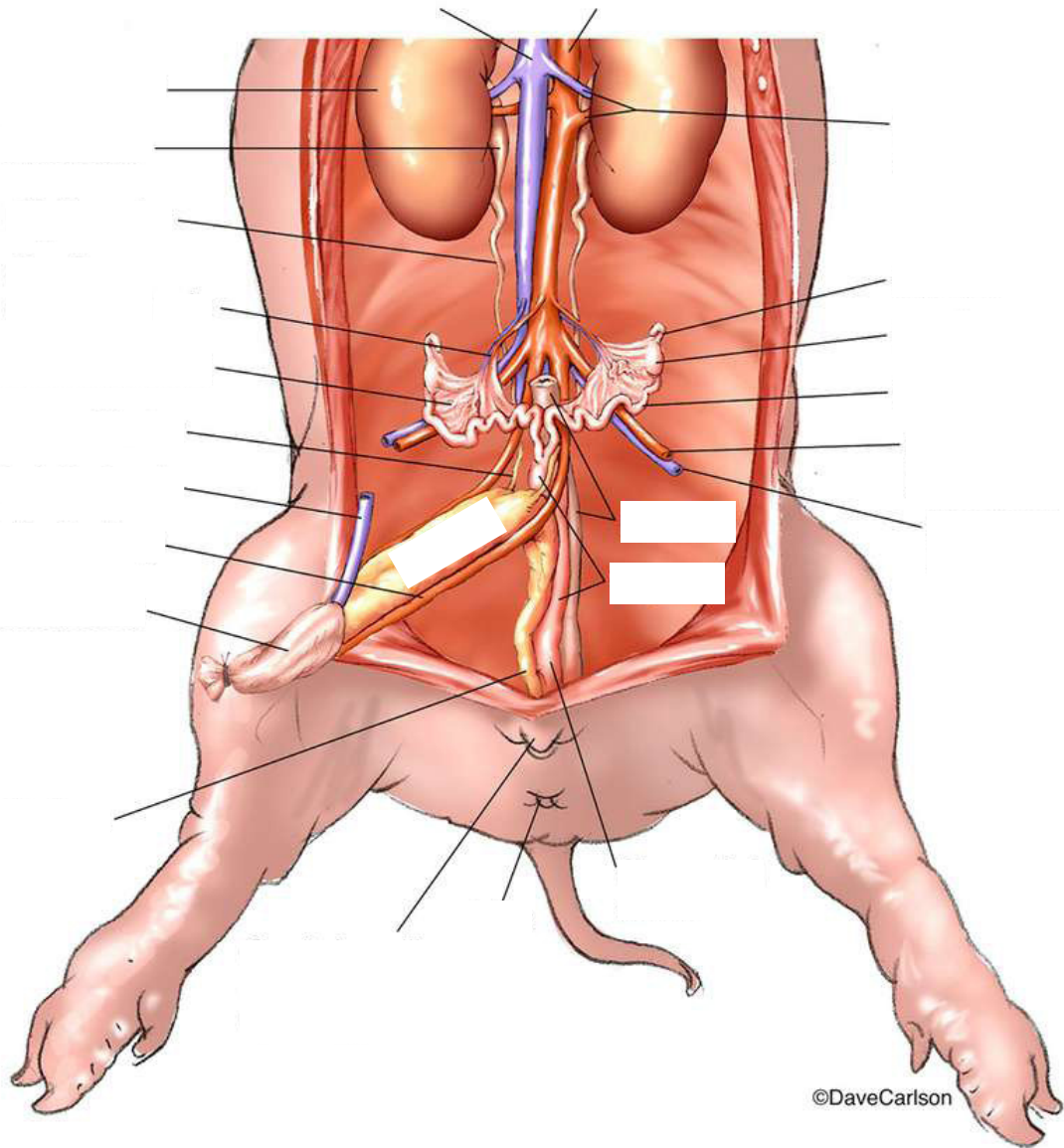
In females, eggs are made and stored in the **ovaries**. A tube called an **oviduct** attaches to each ovary and provides the site where fertilization takes place. Broad ligaments suspend each ovary and oviduct in its place in the abdominal cavity. Fertilized and unfertilized eggs are passed down the oviduct through the **uterine horn** and into the **uterus body**. Fertilized eggs will become implanted in the uterus and begin developing into a fetus. Unfertilized eggs will be passed from the body during menstruation every 21 days. At the base of the uterus body is the **vagina**, or the birth canal. Viable eggs that become babies will be passed through the vagina and out the vaginal orifice during the birthing process.

Female Pig Urogenital Anatomy (teacher copy)

Ask the students to label the major parts of the female pig urogenital system. They can either do this as a learning exercise using the 3D Pig Anatomy app or as a post-learning evaluation. There's a blank diagram on the next page to print and use.

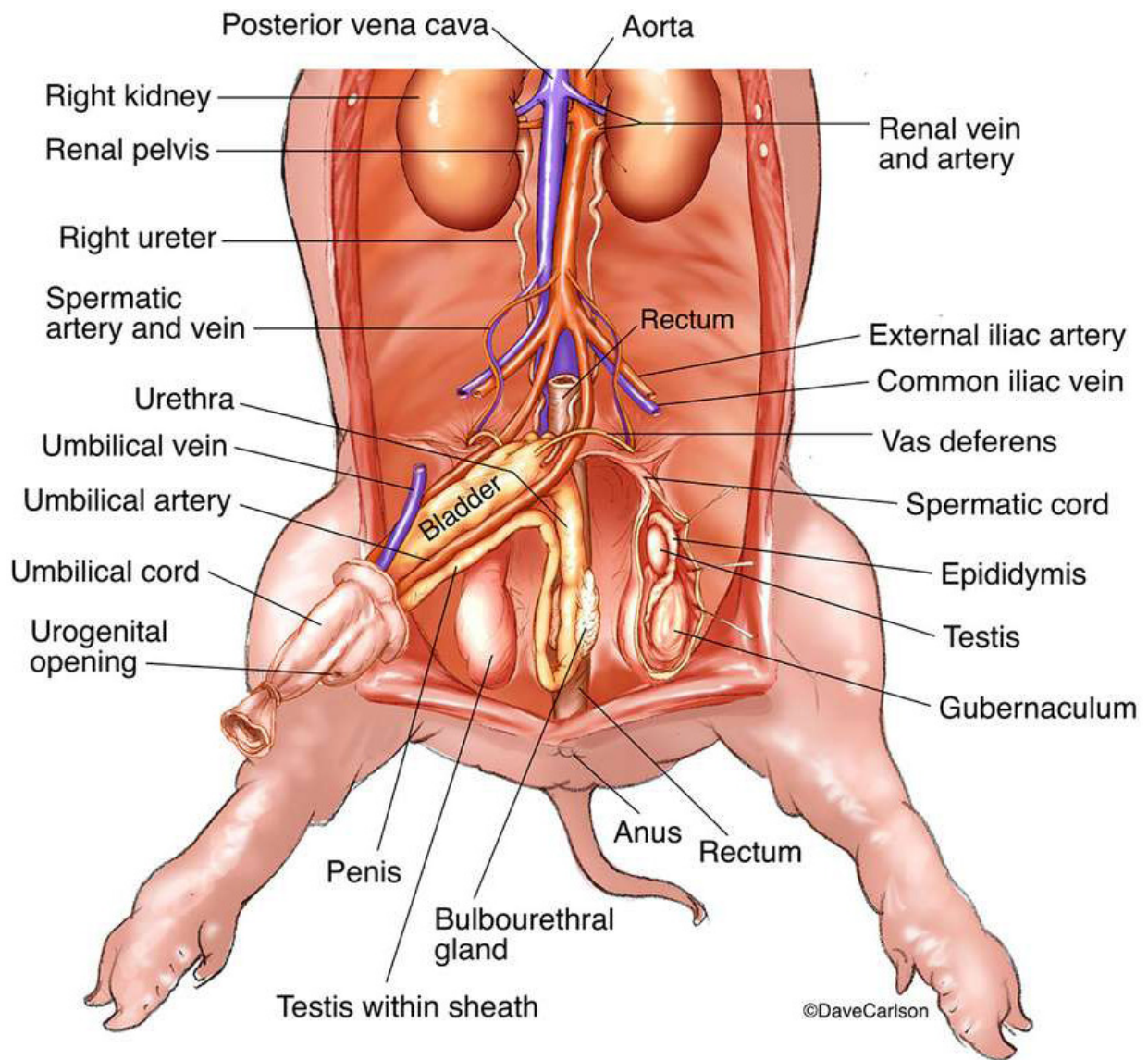


Female Pig Urogenital Anatomy

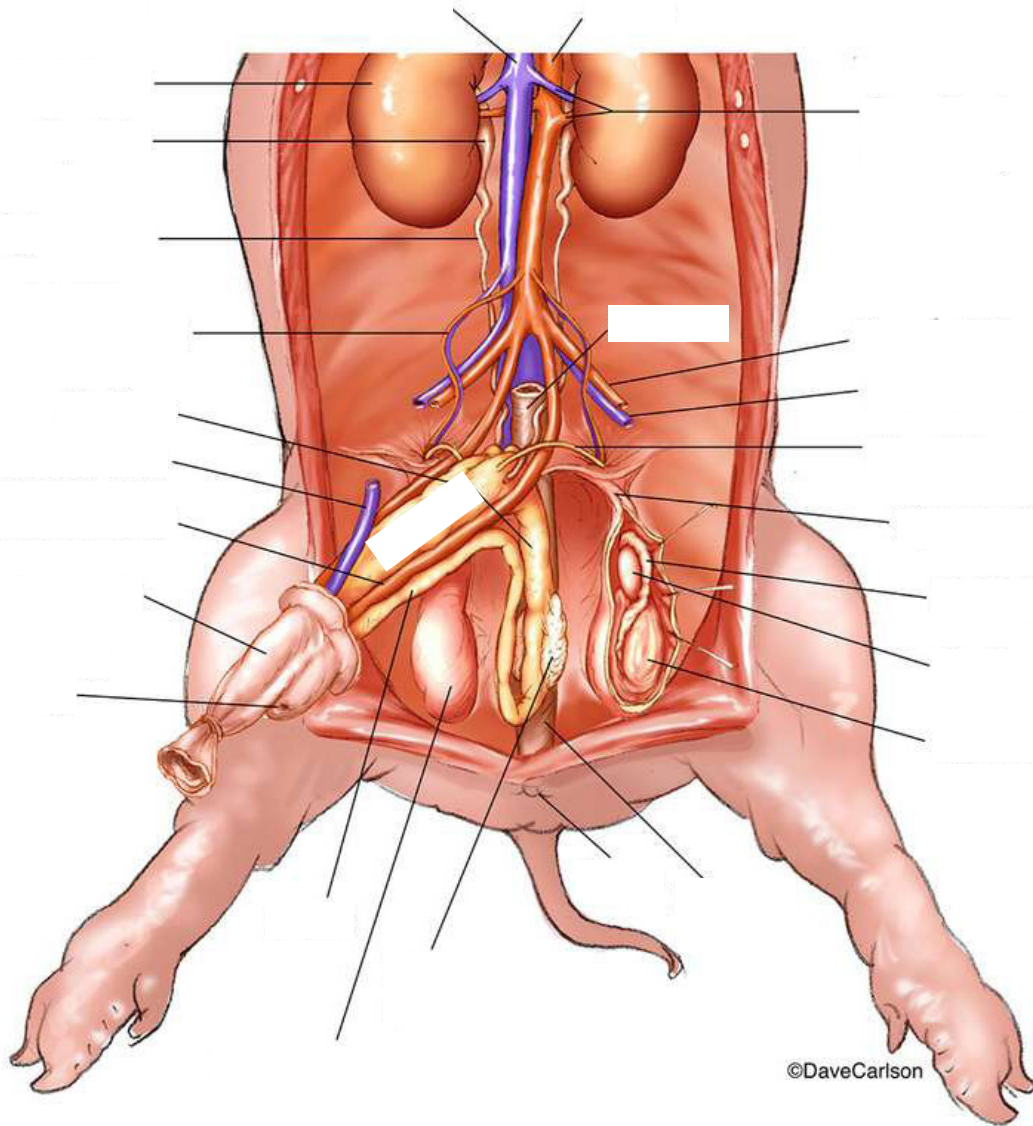


Male Pig Urogenital Anatomy (teacher copy)

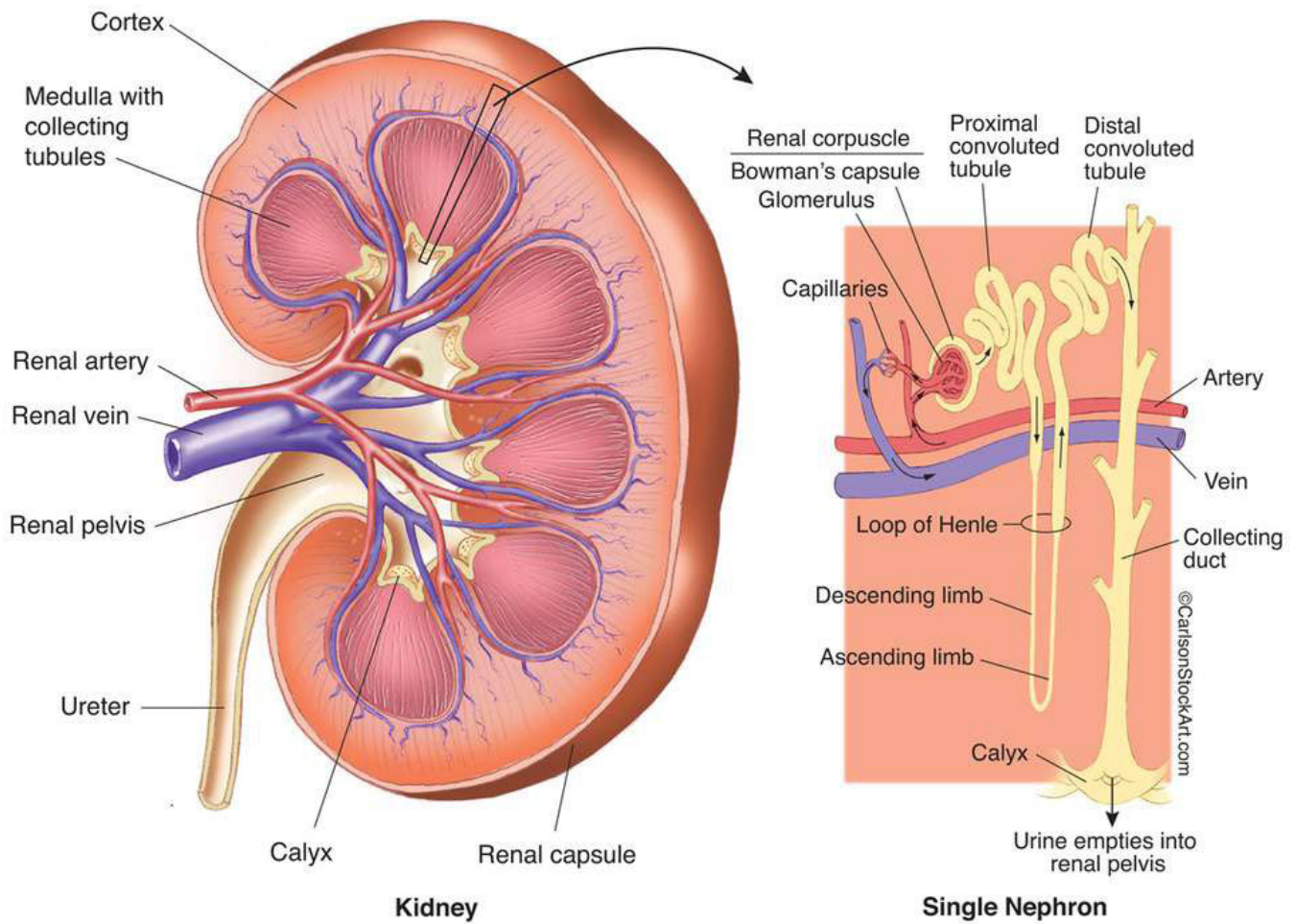
Ask the students to label the major parts of the male pig urogenital system. They can either do this as a learning exercise using the 3D Pig Anatomy app or as a post-learning evaluation. There's a blank diagram on the next page to print and use.



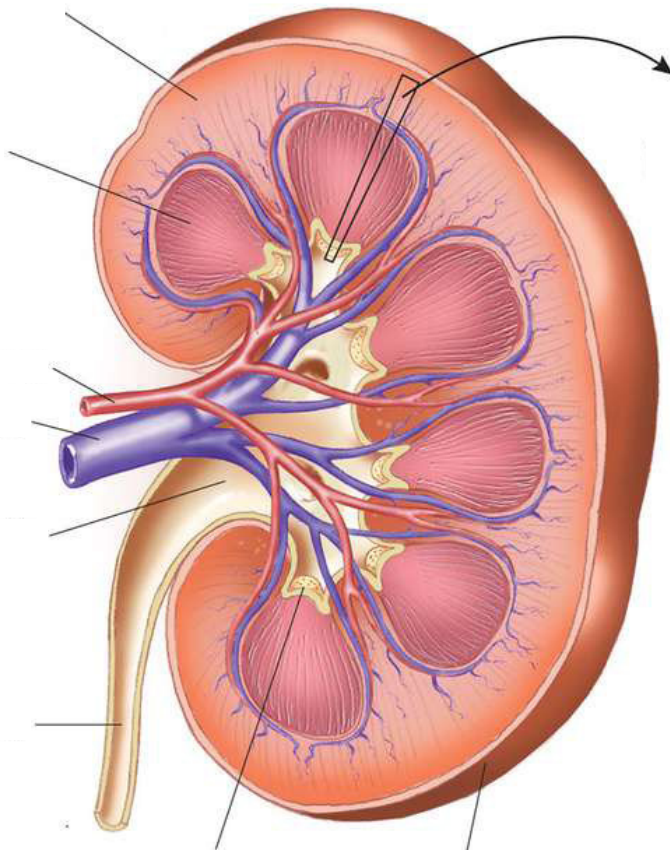
Male Pig Urogenital Anatomy



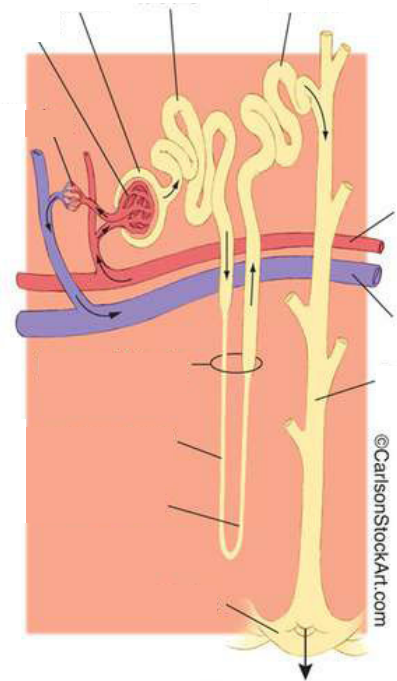
Kidney Anatomy (teacher copy)



Kidney Anatomy (teacher copy)



Kidney



Single Nephron

Lesson 7: Nervous System

TOPIC: Organ systems have complex interrelationships to maintain homeostasis. Homeostasis is maintained through physiological processes.

CONTENT: The pig nervous system.

Goals	Students will be able to: <ul style="list-style-type: none">• Identify the major organs of the pig nervous system• Explain the function and structure of each organ• Explain how the major organs/tissues in the nervous system work together to maintain homeostasis• Explain how the nervous system interacts with other organ systems
Objectives	After this lesson students will describe the structure and function of each organ in the nervous system. They will also explain how the nervous system maintains homeostasis, and explain key similarities and differences between pigs and humans.
Materials	<ul style="list-style-type: none">• 3D Pig Anatomy app by Biosphera• Pig Anatomy Workbook (to accompany 3D Pig Anatomy app)• Paper pig dissection by Getting Nerdy with Mel and Gerdy• Various anatomy worksheets (found within this document)
Introduction	Using the 3D Pig Anatomy app and the paper pig dissections, the teacher will introduce the nervous system.
Development	Questions to support inquiry-based learning: <ul style="list-style-type: none">• How does the nervous system interact with other organ systems?• How do the nervous system organs/tissues help maintain homeostasis?• How does the nervous system maintain internal balance during exercise?• What is the advantage of having specialized nervous tissues?
Practice	Going one urogenital organ at a time, students will work independently or in pairs to fill out the legend of their paper pig dissection by using the 3D Pig Anatomy app to help them identify the different organs.

Nervous System

Brain	<p>Part of the central nervous system (CNS) the brain is the primary organ that controls movement, muscular contraction, respiration, digestion, and interprets sensory input.</p> <p>Major parts of the pig brain include:</p> <ul style="list-style-type: none">• Cerebral hemispheres: separated by a deep fissure and associated with integration.• Cerebellum: lies posterior to the cerebral hemispheres. Has three lobes, two lateral hemispheres and the medial vermis. Responsible for motor coordination and equilibrium.• Medulla oblongata: lies between the cerebellum and the spinal cord. Regulates heart rate, blood pressure, respiration and hormonal secretions.
Neurons	The basic working unit of the brain (CNS). Transmits information to other nerve cells.
Spinal cord	The main pathway to and from the brain. Part of the CNS. Spinal nerves branch off at each region of the spinal cord.
Nerves	Part of the peripheral nervous system (PNS)—specialized fibre bundles that transmit electrical impulses.

During check in:

Highlight key similarities between pigs and other species, especially humans:
Same major nervous system components.

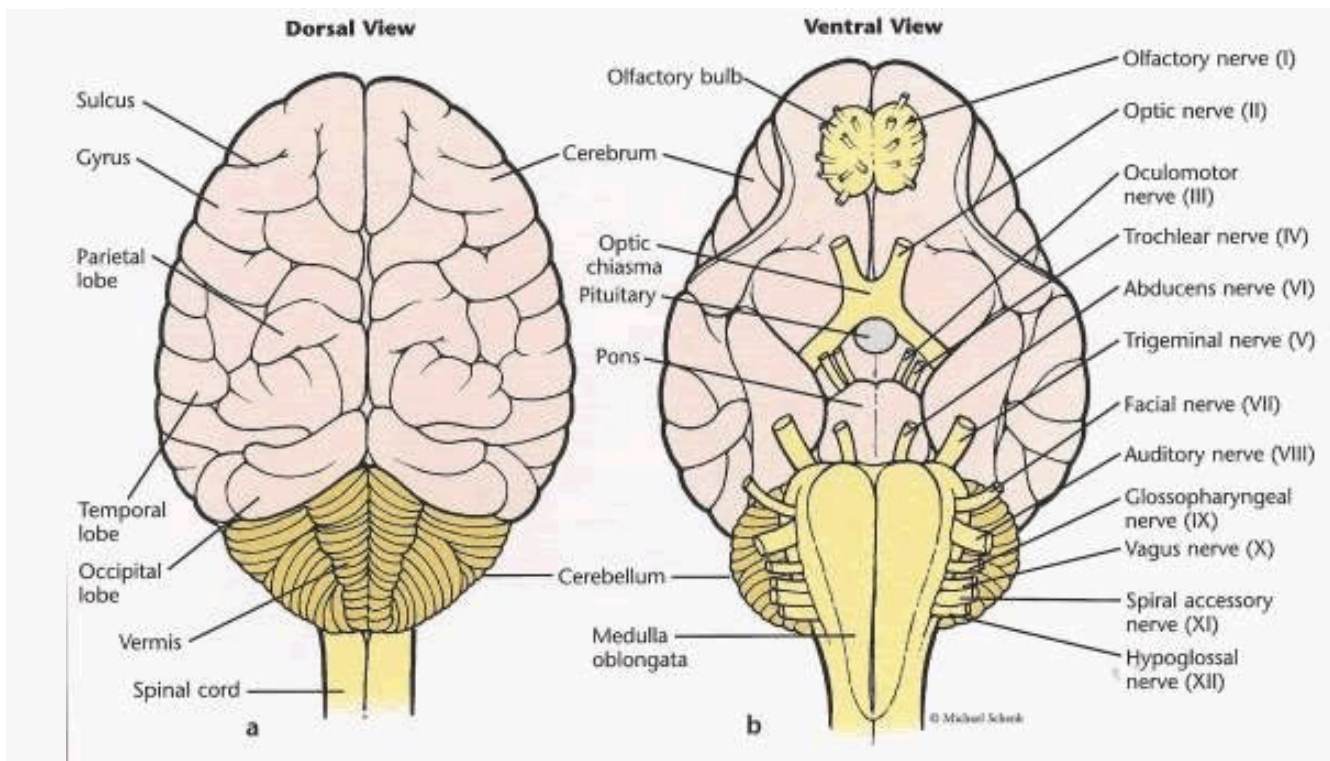
Highlight key differences between pigs and other species, especially humans:
Pigs have a smaller brain.

Development question:

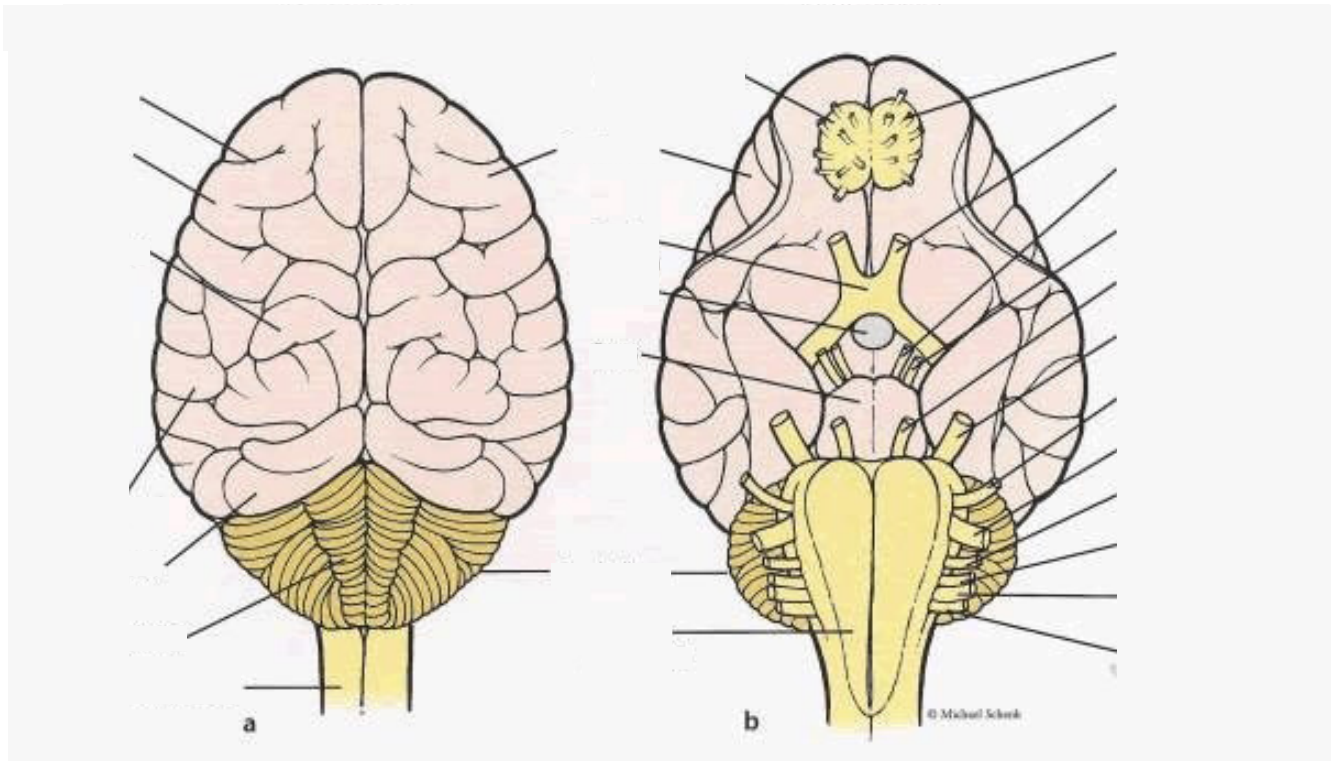
- How does the nervous system interact with other organ systems?
- What is the advantage of having specialized nervous tissue?
- How does the nervous system help maintain homeostasis?

Pig Brain Anatomy (teacher copy)

Ask the students to label the major parts of the pig brain. They can either do this as a learning exercise using the 3D Pig Anatomy app or as a post-learning evaluation. There's a blank diagram on the next page to print and use.

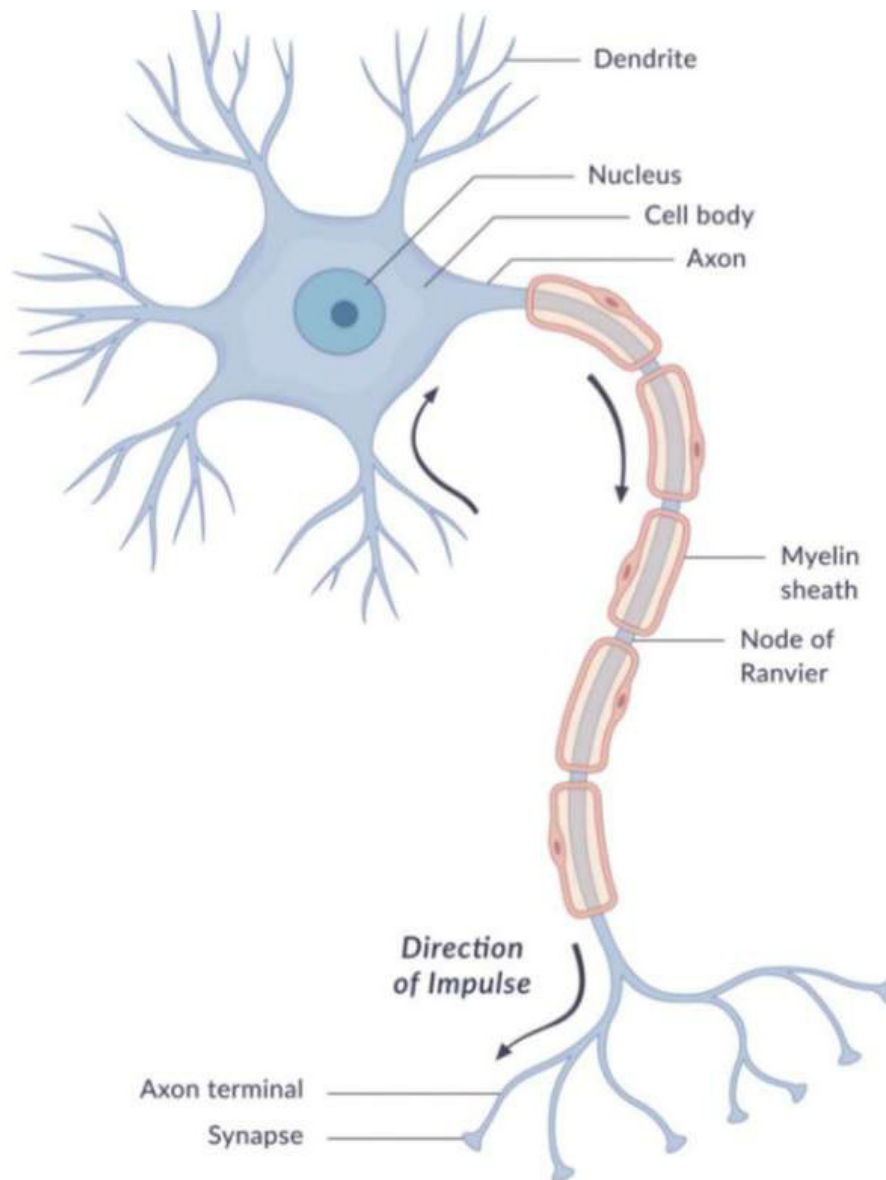


Pig Brain Anatomy

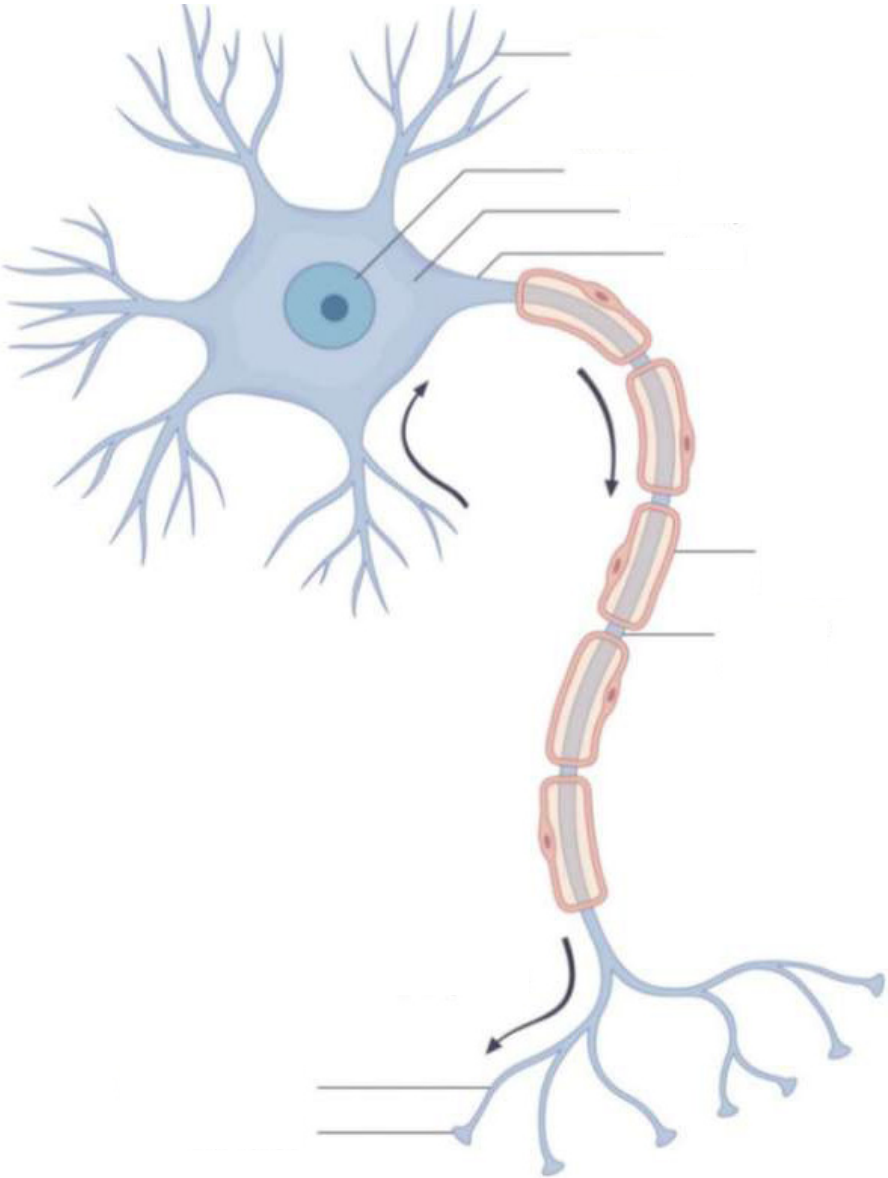


Neuron Anatomy (teacher copy)

Ask the students to label the major parts of a neuron.



Neuron Anatomy



Lesson 8: Endocrine System

TOPIC: Organ systems have complex interrelationships to maintain homeostasis. Homeostasis is maintained through physiological processes.

CONTENT: The pig endocrine system.

Goals	Students will be able to: <ul style="list-style-type: none">• Identify the major organs of the pig endocrine system• Explain the function and structure of each organ• Explain how the major organs in the endocrine system work together to maintain homeostasis• Explain how the endocrine system interacts with other organ systems
Objectives	After this lesson students will describe the structure and function of each organ in the endocrine system. They will also explain how the endocrine system maintains homeostasis, and explain key similarities and differences between pigs and humans.
Materials	<ul style="list-style-type: none">• 3D Pig Anatomy app by Biosphera• Pig Anatomy Workbook (to accompany 3D Pig Anatomy app)• Paper pig dissection by Getting Nerdy with Mel and Gerdy• Various anatomy worksheets (found within this document)
Introduction	Using the 3D Pig Anatomy app and the paper pig dissections, the teacher will introduce the endocrine system.
Development	Questions to support inquiry-based learning: <ul style="list-style-type: none">• How does the endocrine system interact with other organ systems?• How does the endocrine system help maintain homeostasis?• How does the endocrine system maintain internal balance during exercise?• What is the advantage of having specialized endocrine tissues?
Practice	Going one endocrine organ at a time, students will work independently or in pairs to fill out the legend of their paper pig dissection by using the 3D Pig Anatomy app to help them identify the different organs.

Endocrine System

Adrenals	Produce adrenaline and cortisol (stress hormone).
Hypothalamus	The hypothalamus produces a variety of hormones that are responsible for body temperature, hunger, moods and the release of hormones from other glands; and also controls thirst and sleep.
Ovaries	Produce estrogen and progesterone—female sex hormones.
Pancreas	Produces insulin (which reduces blood sugar) and glucagon (which increases blood sugar).
Pituitary	The pituitary gland controls the function of most other endocrine glands and is therefore sometimes called the master gland. It produces a wide variety of different hormones that influence other endocrine glands.
Testes	Produce testosterone—male sex hormone.
Thyroid	The thyroid gland produces hormones that regulate the body's metabolic rate controlling heart, muscle and digestive function, brain development and bone maintenance.

During check in:

Highlight key similarities between pigs and other species, especially humans:
Same major endocrine glands and function.

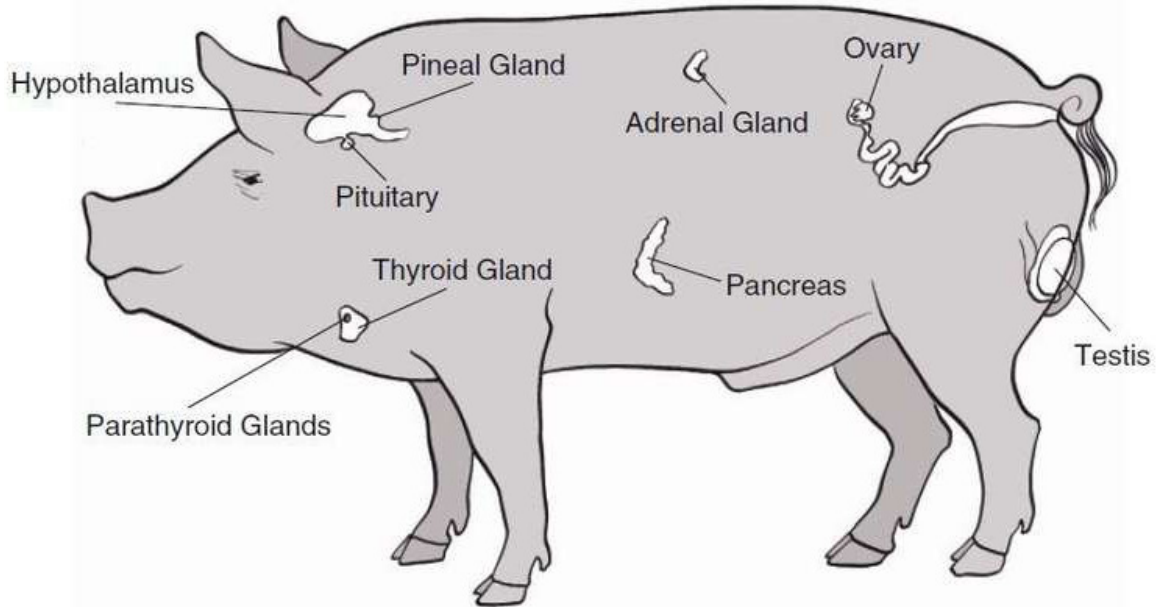
Highlight key differences between pigs and other species, especially humans:
No major differences.

Development question:

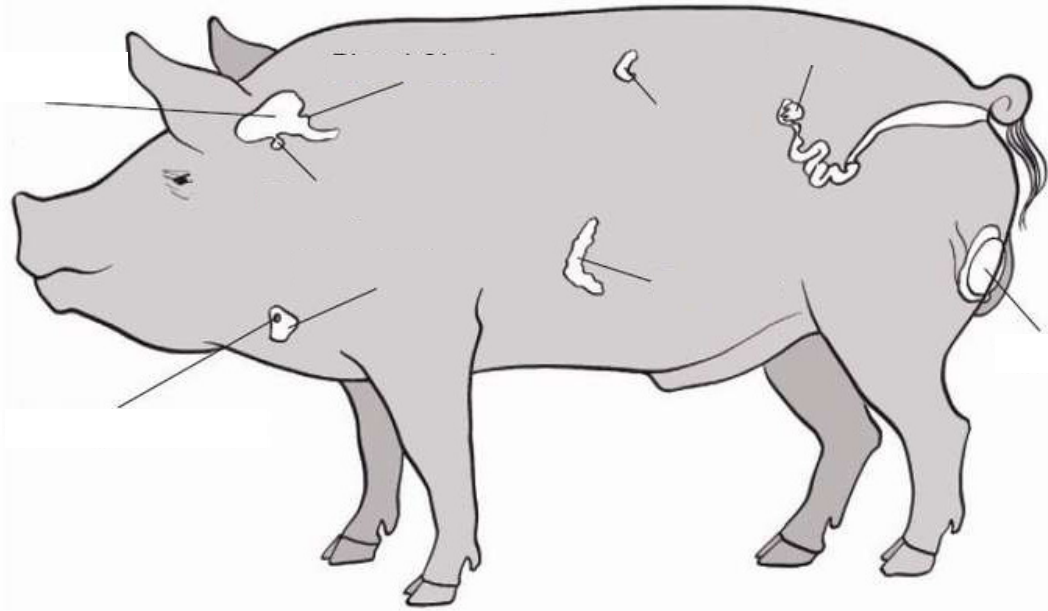
- How does the endocrine system interact with other organ systems?
- What is the advantage of having specialized endocrine tissue?
- How does the endocrine system help maintain homeostasis?

Endocrine System (teacher copy)

Ask the students to label the major parts of the pig endocrine system. They can either do this as a learning exercise using the 3D Pig Anatomy app or as a post-learning evaluation. There's a blank diagram on the next page to print and use.



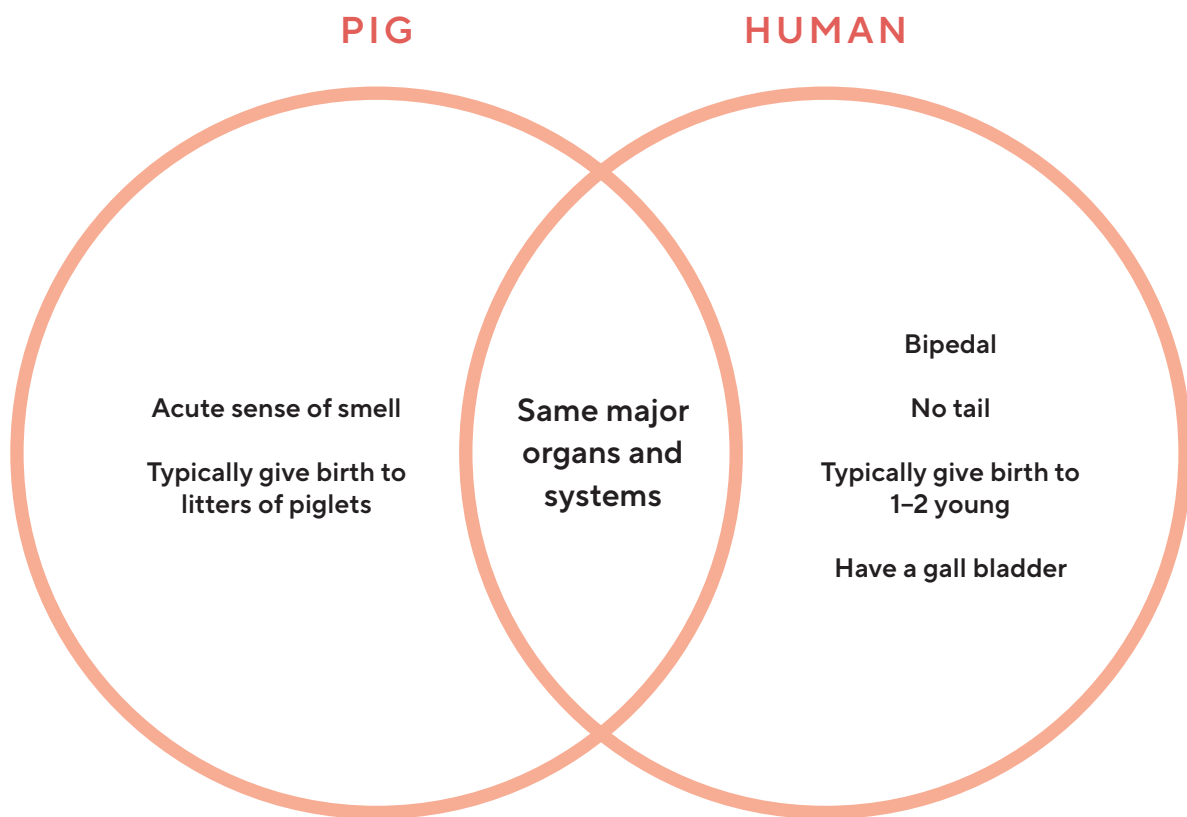
Endocrine System



Similarities and Differences Between Pigs and Humans

ACTIVITY:

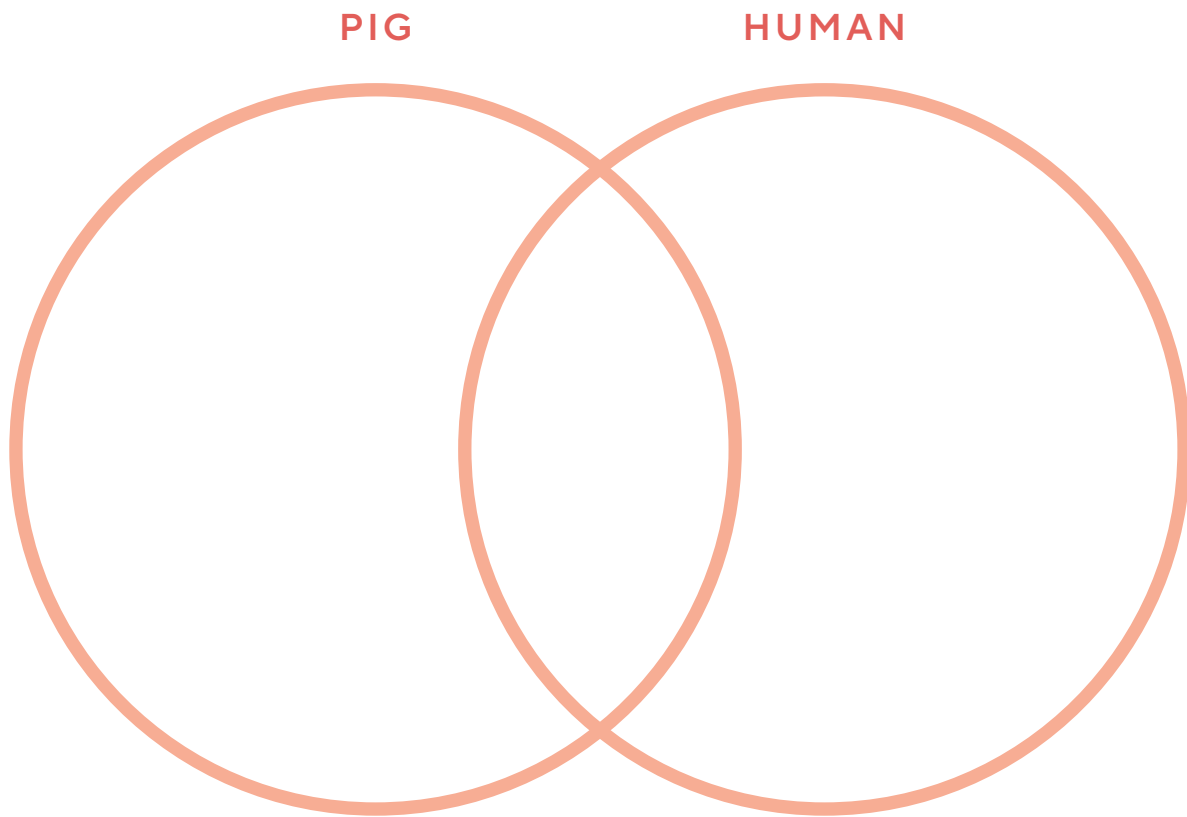
Ask the students to get into pairs, reflect on what they've learned about pig adaptations and organ systems, and fill out the Venn diagram below (some examples are given below but this is not a complete list—blank student copy is on next page).



KEY DISCUSSION POINT AFTER THE ACTIVITY:

While there are some important differences between pigs and humans because we are adapted to different natural habitats, there are also many similarities. We both have hearts, lungs, a digestive system, nerves, muscles, bones, blood vessels, etc. We are more alike than we are different once you look inside our bodies! So, it's important that we respect pigs and avoid causing them harm, especially in science where they are commonly used as 'animal models'.

Similarities and Differences Between Pigs and Humans



How Do Organ Systems Work Together?

Ask students how they think the major organ systems work together.

SPECIFIC QUESTIONS CAN INCLUDE:

1. How does oxygen get into the bloodstream? How do the respiratory and circulatory systems connect with each other?

Gas exchange in the alveoli of the lungs—the respiratory and circulatory systems are linked via the capillary network that surrounds the alveoli.

2. How do nutrients from the rat's food get into the bloodstream? How do the digestive and circulatory systems connect with each other?

Nutrient exchange between small intestine and bloodstream—links the digestive and circulatory systems via the capillary network that surrounds the villi in the small intestine.

3. How are harmful substances filtered from the blood? How do the circulatory and digestive/urinary systems connect with each other?

*Hepatic portal system of the liver—links digestive and circulatory systems.
Blood filtration in the kidneys—links urinary and circulatory systems.*

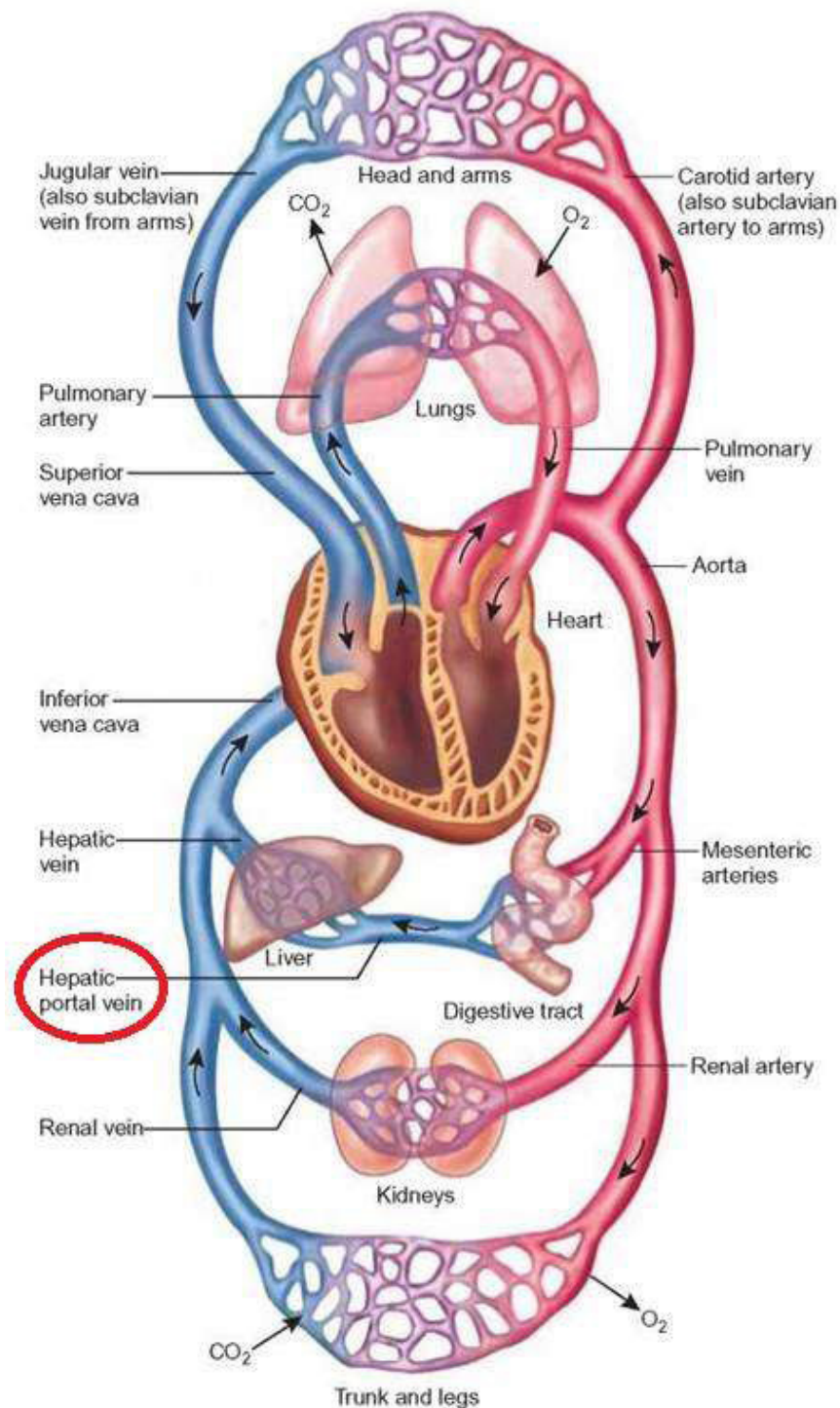
4. How do hormones interact with other body systems?

Adrenaline/cortisol from adrenal glands increase blood glucose and provide energy to muscles. Insulin and glucagon from pancreas regulate blood sugar levels.

5. How do the nervous and musculoskeletal systems interact with each other?

Nerve impulses travel from the brain, down the spinal cord to the peripheral nerves. Peripheral nerves send signals to muscles so they contract. The opposite also happens, so when we touch something, nerve impulses travel along our peripheral nerves, along our spinal cord, to our brain where the sensory information is processed. Reflexes don't need any brain activity—for example, when we touch something very hot, we react and pull our hand away without even thinking about it. In that case the nerve impulse travels from nerves in our fingers to our spinal cord and straight back to our muscles so that we pull our hand away from the hot surface.

Links Between Circulatory, Respiratory, Digestive, and Urinary Systems



Example Evaluation Questions and Activities

ORGAN SYSTEMS ACTIVITY

Give students both a male and female paper pig dissection and ask them to a) find the number labels that correspond to the major organs of each body system (you can be specific with this list; for example, ask them which of the numbered labels on the paper dissections correspond to heart, liver, kidneys, etc.), and b) identify which paper pig is male and which is female.

RESPIRATORY SYSTEM

What is the correct order of airflow for pigs when they inhale?

- Bronchial Tube > Trachea > Bronchioles > Alveoli
- Trachea > Bronchioles > Bronchial Tube > Alveoli
- Trachea > Bronchial Tube > Bronchioles > Alveoli
- Bronchioles > Trachea > Bronchial Tube > Alveoli

Explain how gas exchange happens in the lungs:

Air flows into the alveoli and oxygen molecules pass across the cell wall of the alveoli, across the cell wall of the surrounding capillaries, and into the blood stream. Carbon dioxide passes in the opposite direction (from the bloodstream to the alveoli) so that it can be breathed out.

True or False: The diaphragm contracts on an exhale.

False.

CIRCULATORY SYSTEM

True or False: Pulmonary veins carry oxygenated blood from the lungs to the left atrium.

True.

Which of the following is correct?

- Atrium contracts, sending oxygenated blood to the brain from the left ventricle. Blood flows through the pulmonary arteries to reach the head.
- Ventricle contracts, sending deoxygenate blood to the brain from the right ventricle. Blood flows through carotid arteries to reach the head.
- Ventricle contracts, sending deoxygenated blood to the lungs from the left atrium. Blood flows through the pulmonary arteries to reach the head.
- Ventricle contracts, sending oxygenated blood to the brain from the left atrium. Blood flows through carotid arteries to reach the head.

DIGESTIVE SYSTEM

Which of the following make up the alimentary canal?

- Mouth, Esophagus, Stomach, Small Intestine, Large Intestine.
- Gastric glands, Liver, Pancreas, Intestinal glands.

Write a detailed summary of the major body parts and organs that a pig's food passes through, from the moment it enters the mouth, to the moment it is pooped out.

Mouth → esophagus → stomach (chemical and mechanical digestion) → pancreas (secretes pancreatic juices and enzymes to help with food breakdown) → small intestine (chemical digestion and food absorption via villi in SI walls) → liver (filters digestive products from blood) → large intestine (water and food absorption)

How many lobes does a pig's liver have?

- 2
- 3
- 4
- 5

UROGENITAL SYSTEM

Which of these are correct? (check all that apply)

- Kidney: filters blood and produces urine
- Kidney: stores urine
- Urinary bladder: expels urine, faeces, sperm and eggs
- Urinary bladder: stores urine

What is the name of the duct in *male* pigs that transports urine from the kidneys to the bladder, *and* sperm from the testes?

Ureter/urogenital duct/Wolffian duct

HOW DO THE BODY SYSTEMS CONNECT?

How do the respiratory system and circulatory system connect and work together in a fully functioning pig?

Gas exchange between lungs and bloodstream across the walls of alveoli and capillaries.

How do the digestive system and circulatory system connect and work together in a fully functioning pig?

Via the liver and hepatic portal system:

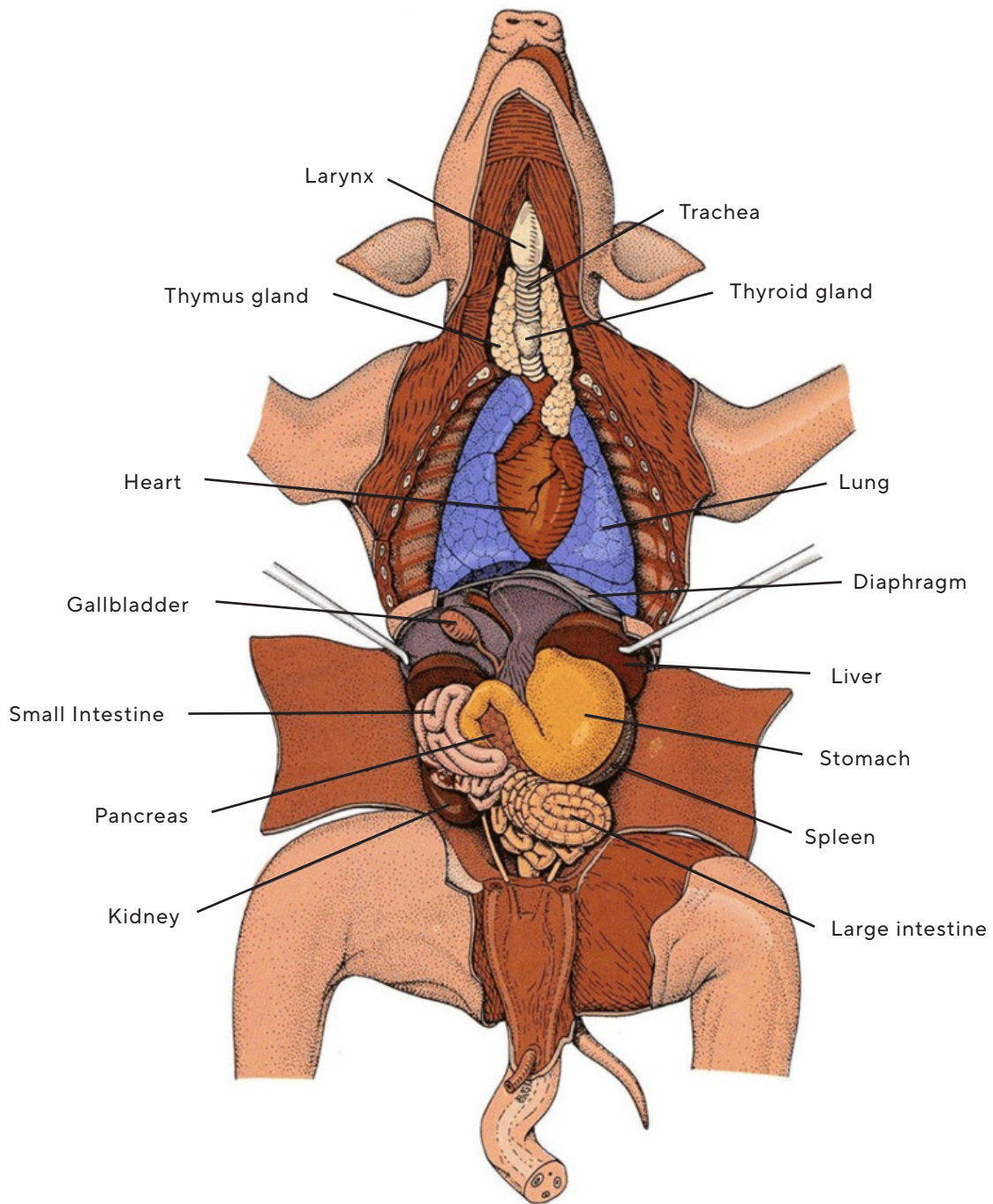
1. Small intestine absorbs products of digestion
2. Nutrient molecules travel in hepatic portal vein to liver
3. Liver monitors blood content
4. Blood enters general circulation by way of hepatic vein

How do the urogenital system, digestive system and circulatory system connect and work together in a fully functioning pig?

Via the kidneys and the renal portal system:

1. Nutrient and waste molecules in the bloodstream travel in renal portal vein to the kidneys
2. Kidneys filter out harmful substances like urea and carbon dioxide, which are passed outside as urine.

Fetal Pig Anatomy Quiz (Teacher Copy)



Fetal Pig Anatomy Quiz

