



Pig Anatomy Workbook

ACCOMPANIES 3D PIG ANATOMY APP BY BIOSPHERA



Animal Welfare
Institute

AWI wishes to thank Elisabeth Ormandy for granting us permission to use and share these lesson plans in the hopes that more classrooms can replace once-living specimens with alternatives. This content was generated outside of AWI and we do not warrant the accuracy or timeliness of any information contained in this version. Please refer to your school district's requirements to ensure alignment with the relevant standards.

TABLE OF CONTENTS

Learning objectives.....	4
Getting to know 3D pig anatomy.....	6
Musculoskeletal system.....	17
Respiratory system.....	21
Circulatory system.....	32
Digestive system.....	39
Urinary system.....	57
Nervous system.....	67
Endocrine system.....	72
How do organ systems work together?.....	81
Similarities between pigs and humans.....	83

Learning Objectives

- 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

Introducing the Pig!



In this lab, we will be taking a look at several body systems in the pig.

Pigs are **mammals**, just like humans. Keep this in mind as you explore the various organs that make up pigs bodies!

The body systems we will explore are:

Musculoskeletal

Respiratory

Circulatory

Digestive

Urinary

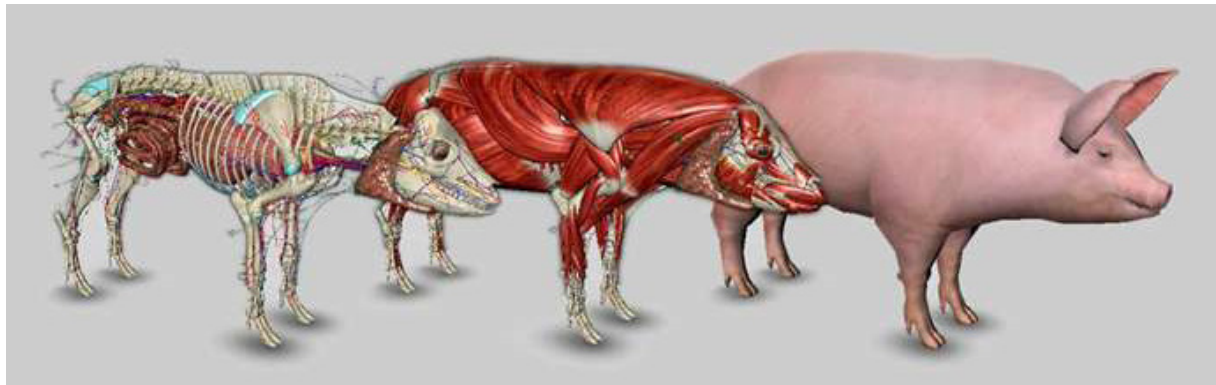
Nervous

Endocrine

Getting To Know 3D Pig Anatomy

BY BIOSPHERA

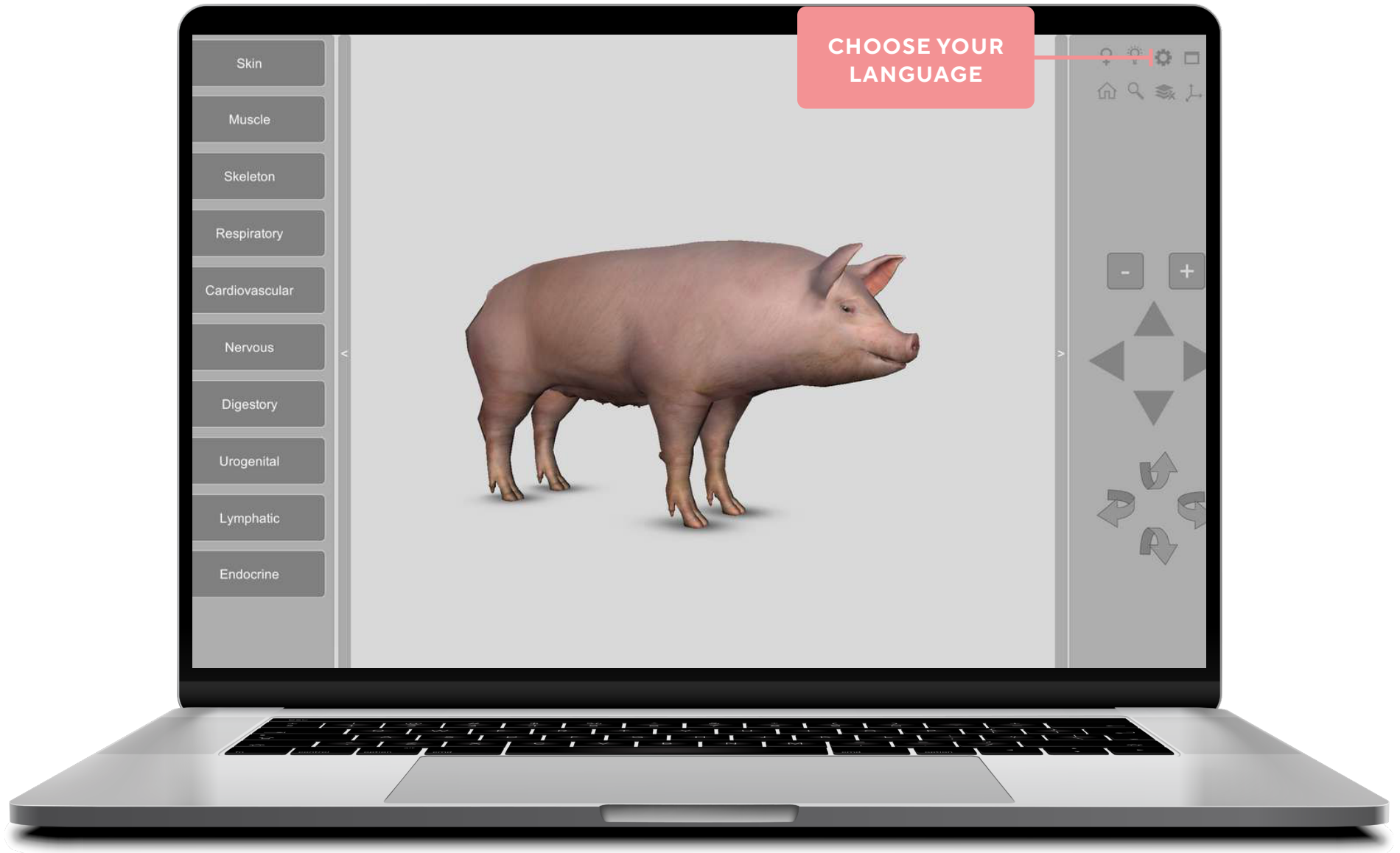
The app is available for iPads, Android tablets, and desktop: biosphera.com

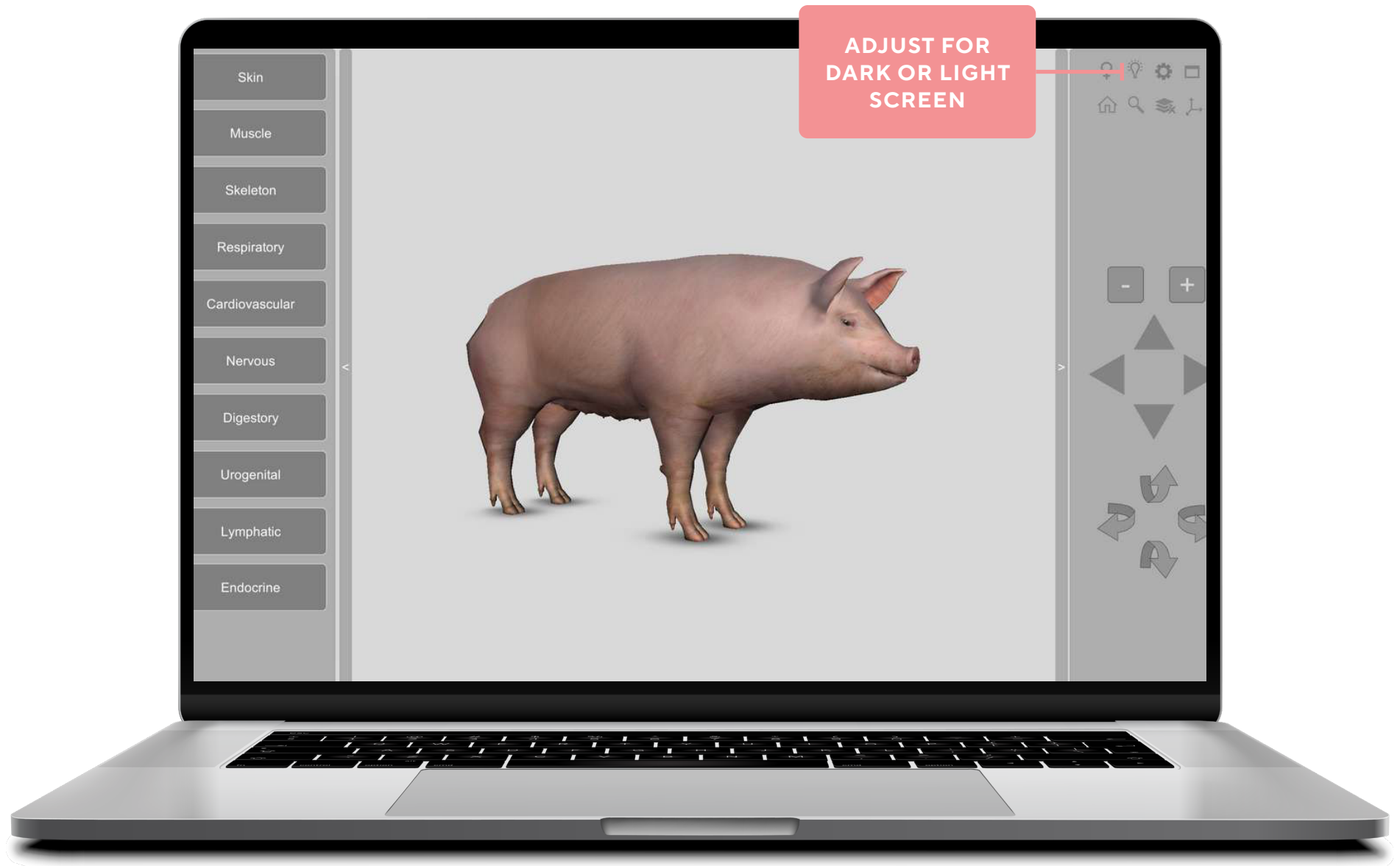


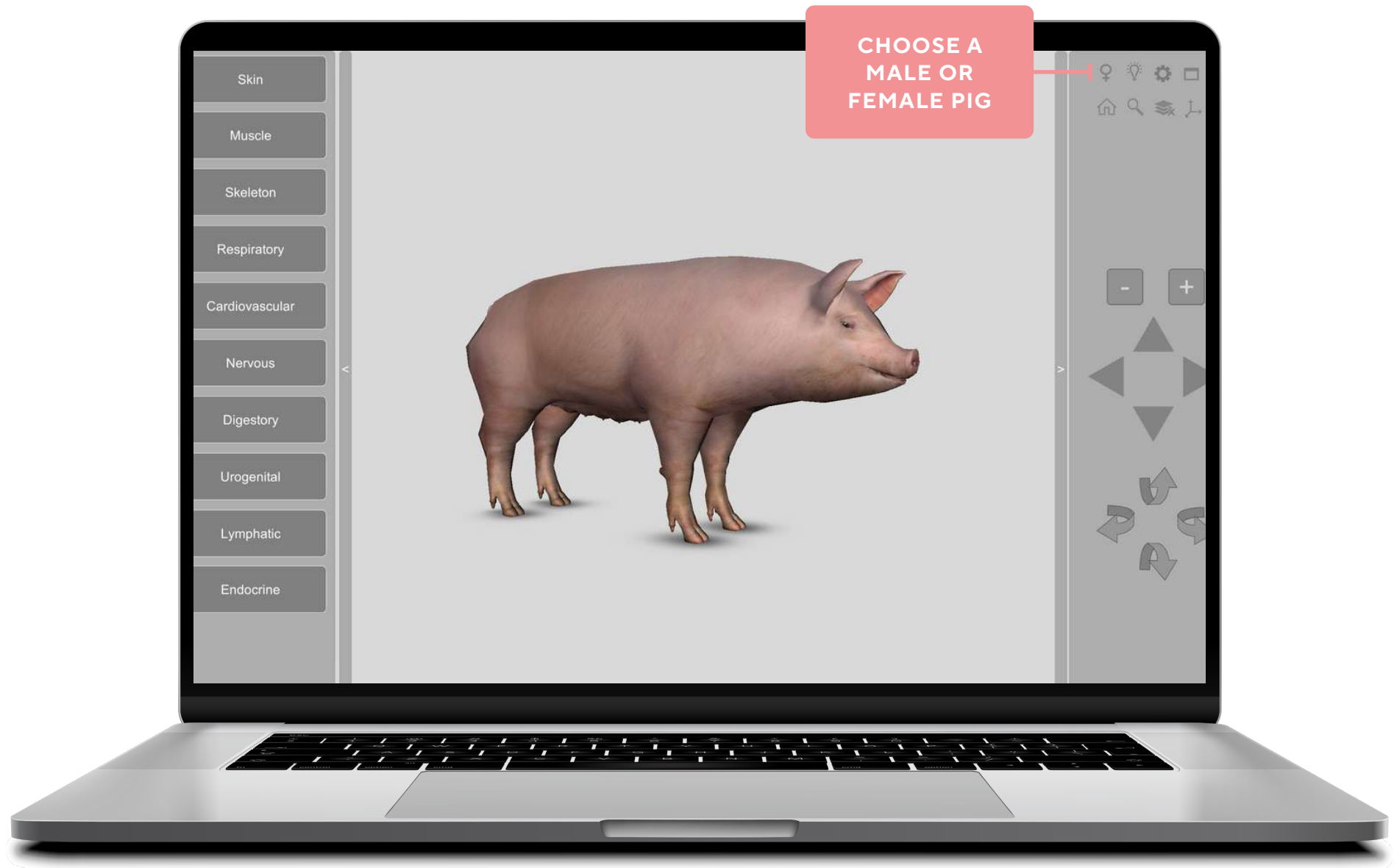
Lets get comfortable with the app!

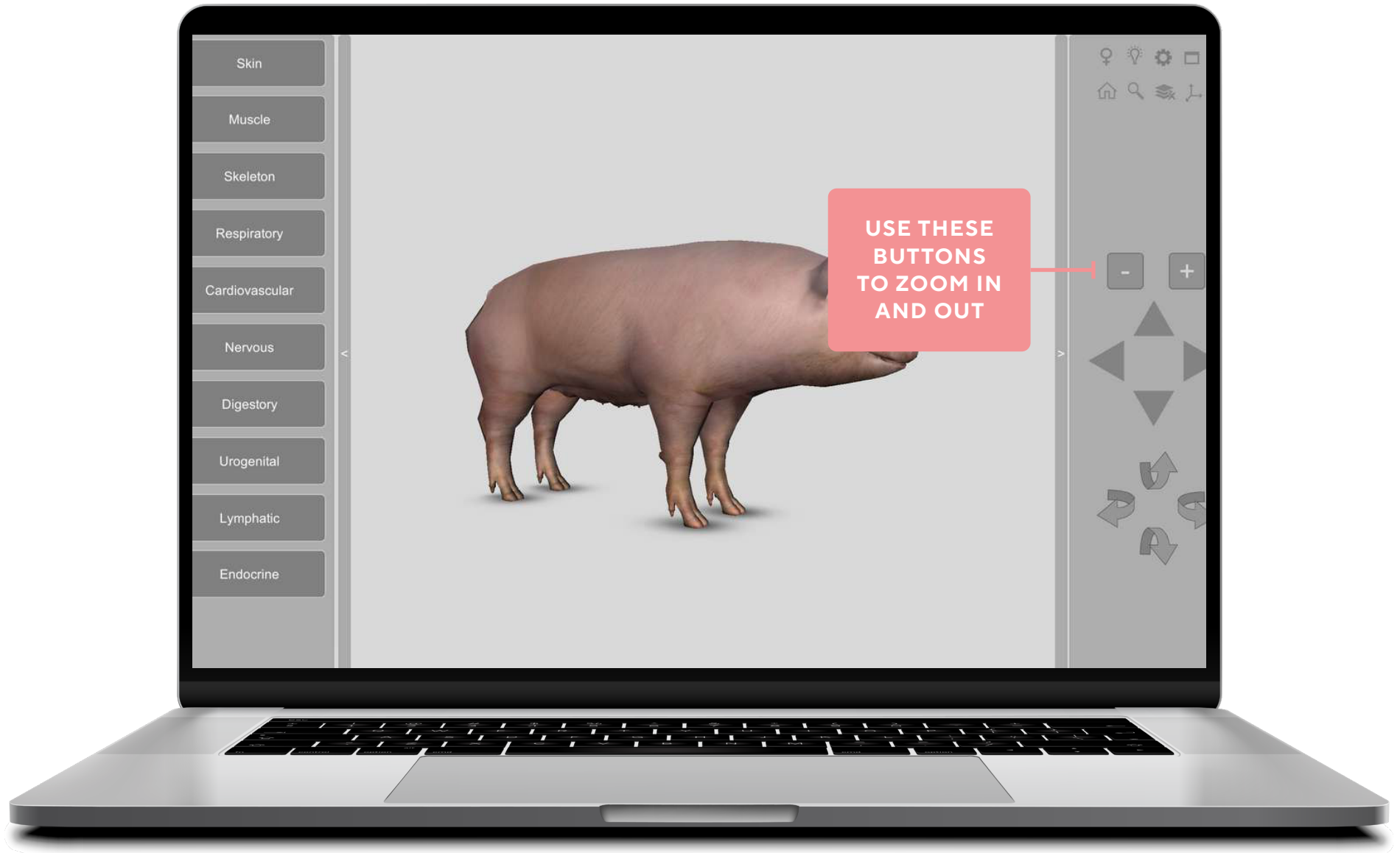
Make sure everyone in your group takes a few minutes to explore the app.

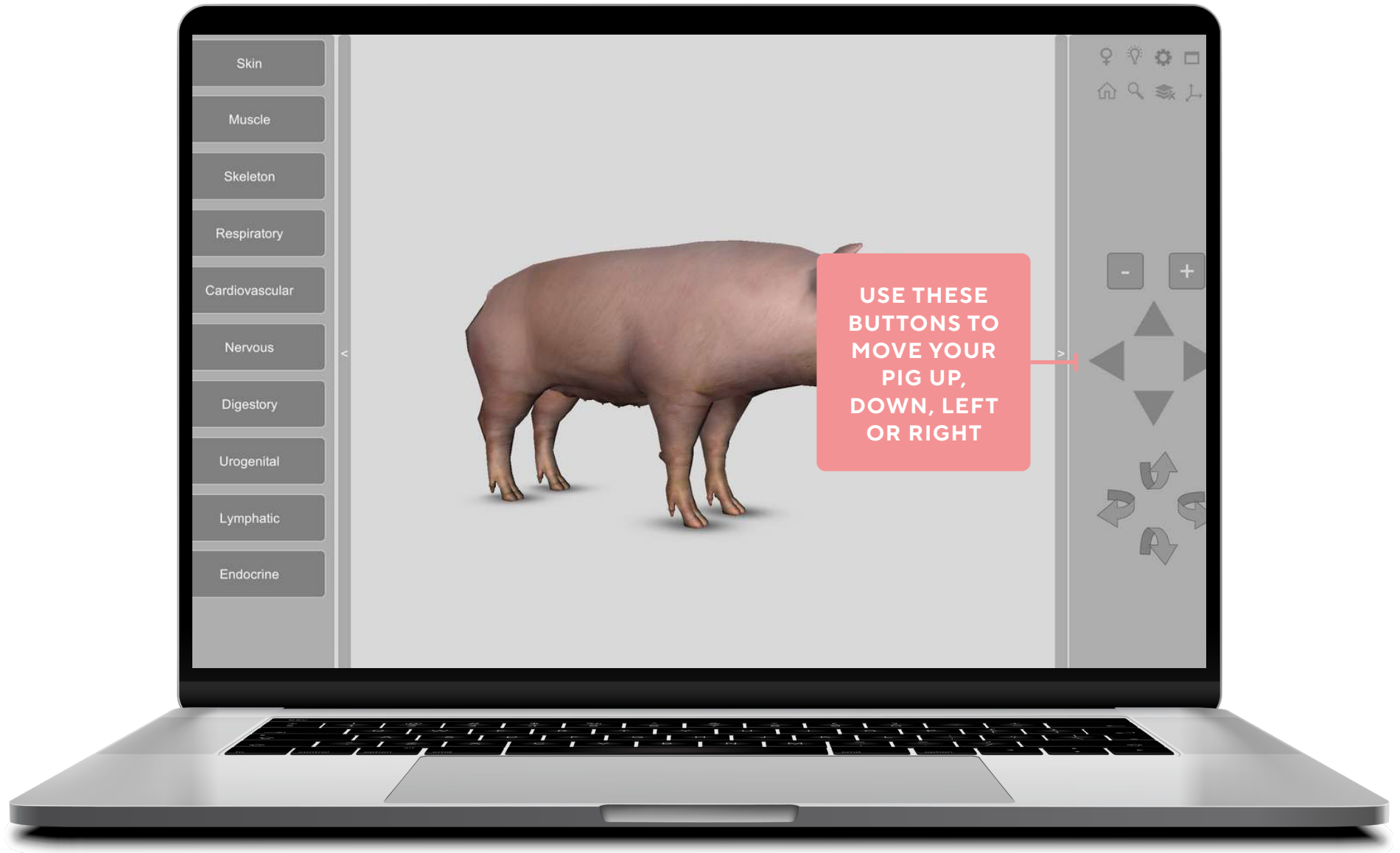
Press buttons, move the model around, and touch/hold the organs...
see what happens!

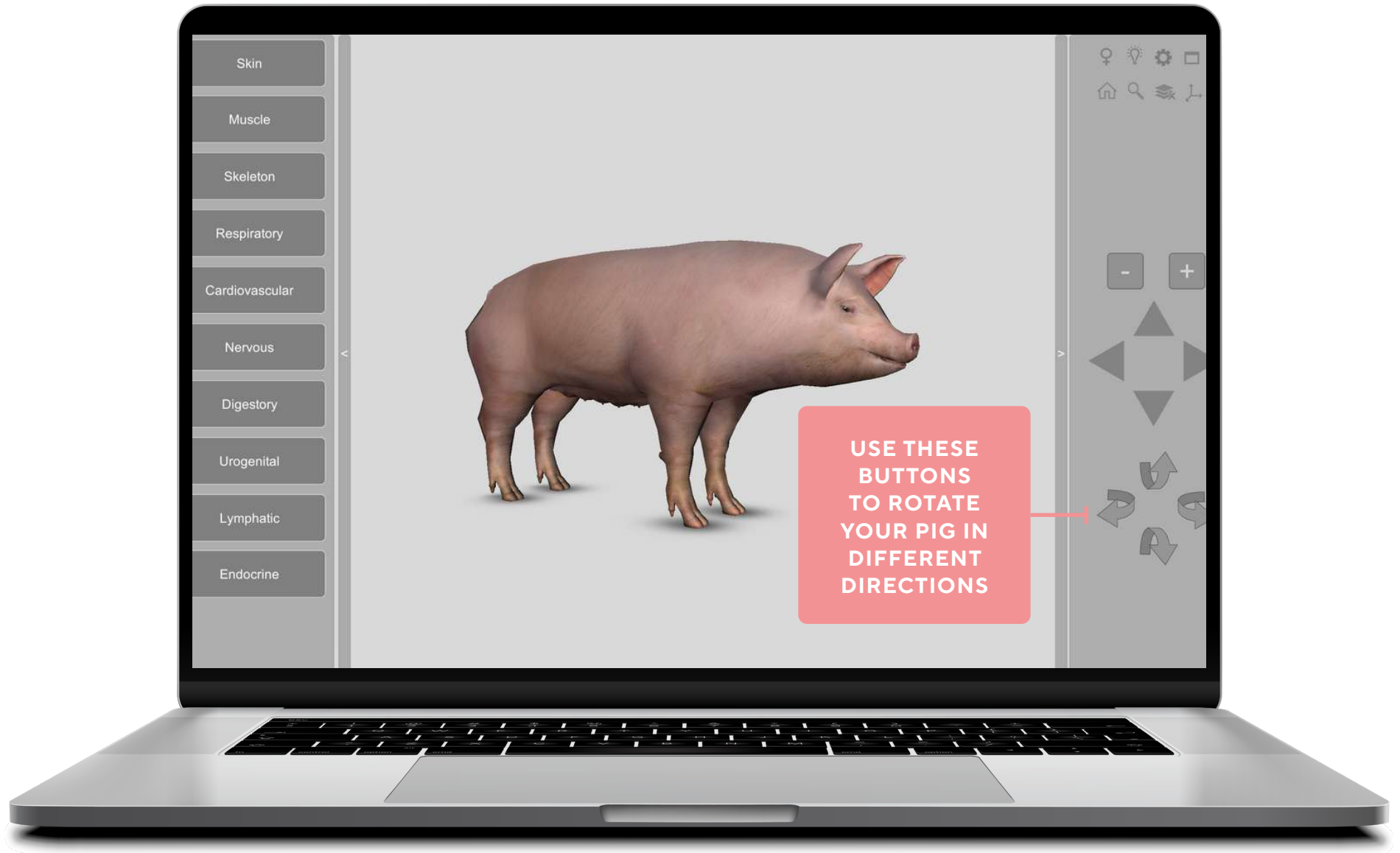




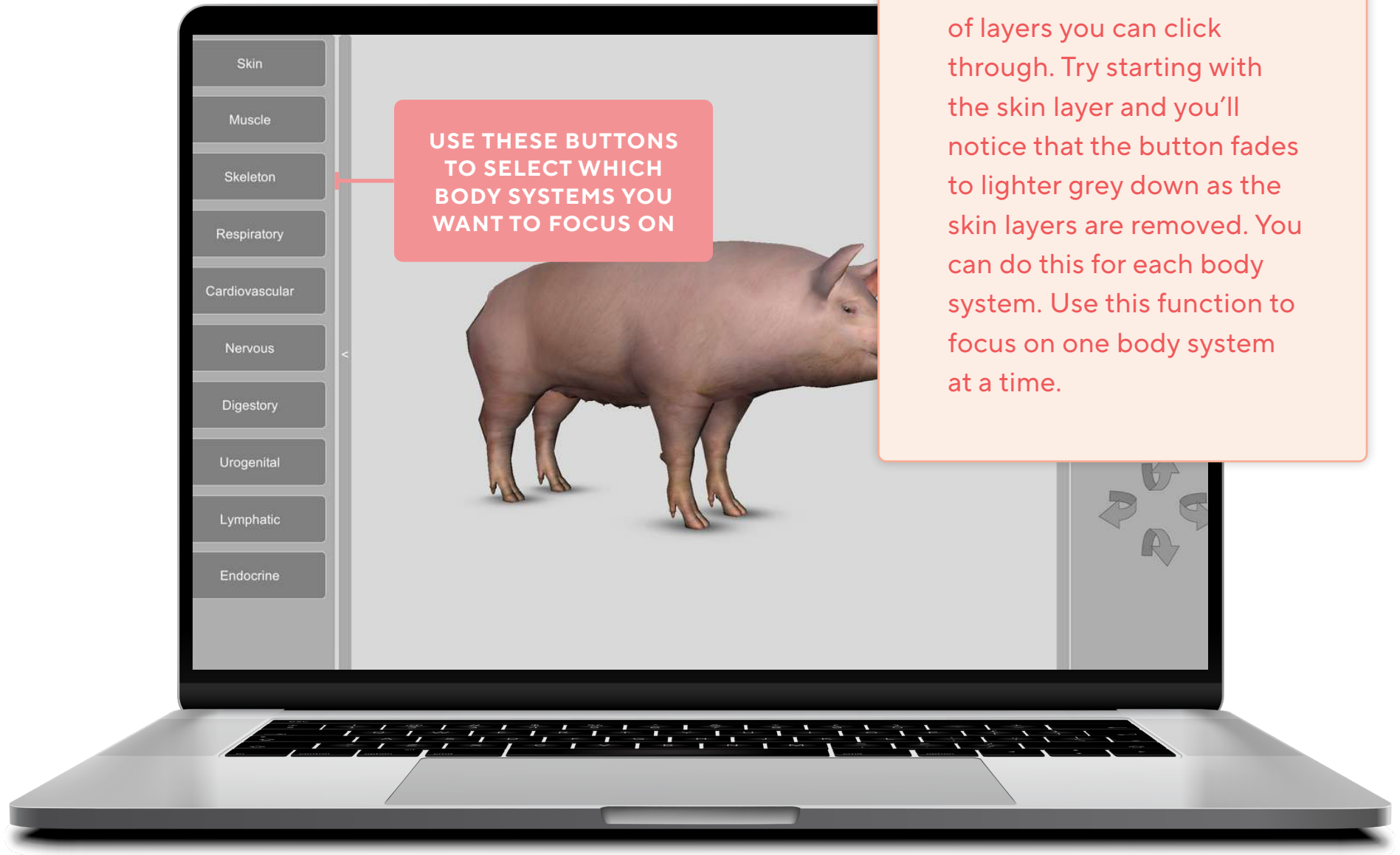








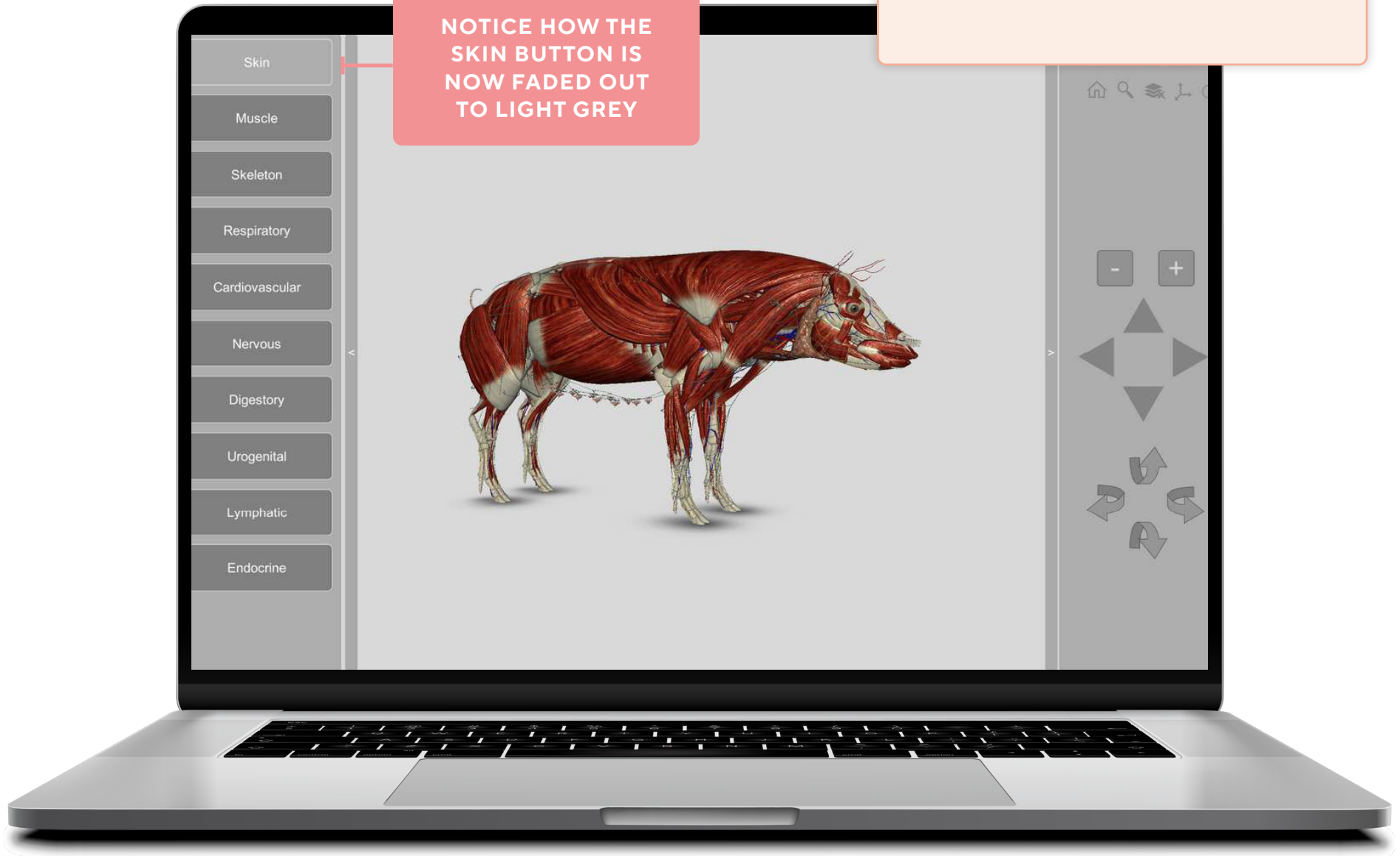
USE THESE
BUTTONS
TO ROTATE
YOUR PIG IN
DIFFERENT
DIRECTIONS



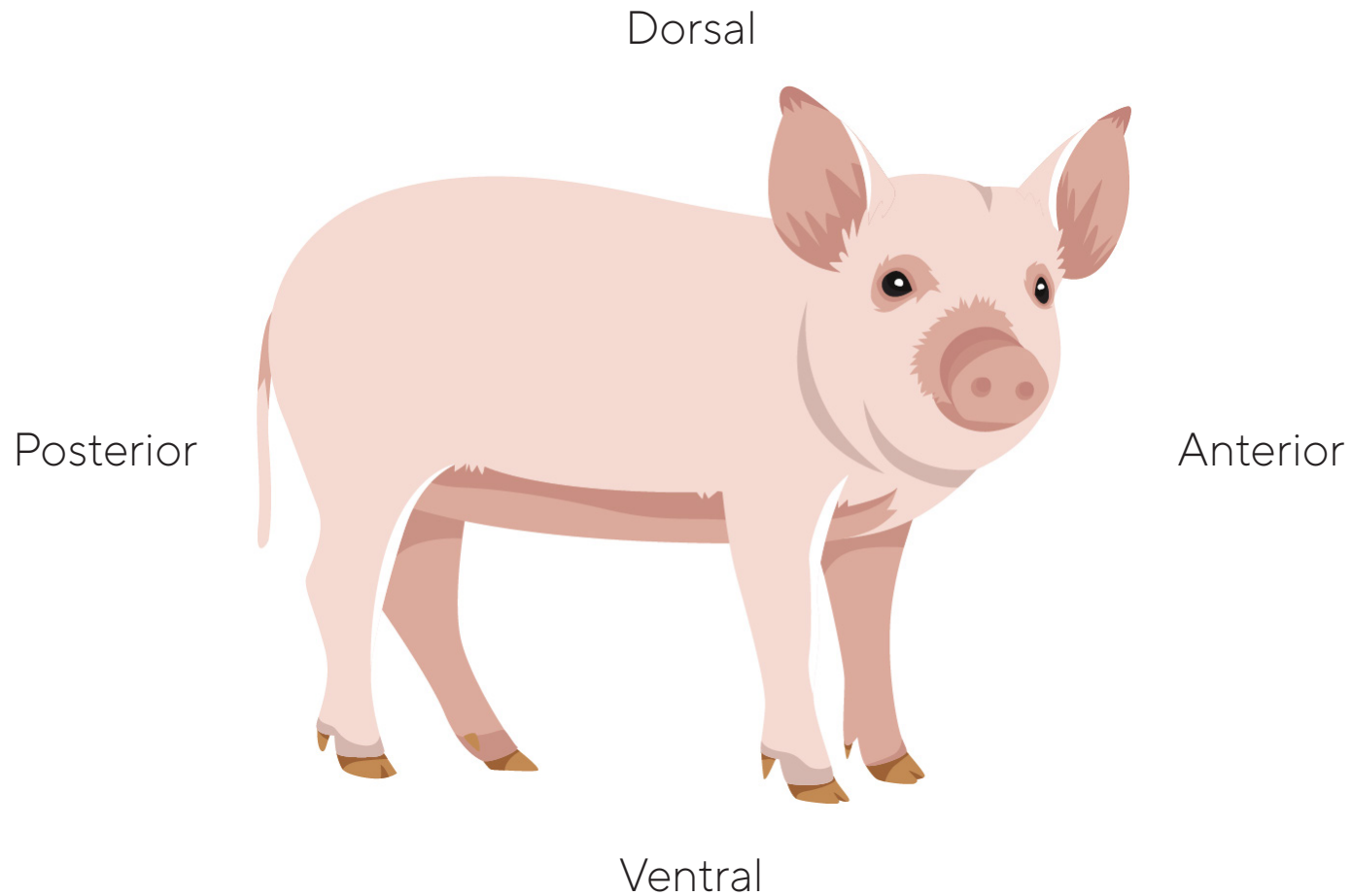
Each grey body system button displays a progress bar to indicate the number of layers you can click through. Try starting with the skin layer and you'll notice that the button fades to lighter grey down as the skin layers are removed. You can do this for each body system. Use this function to focus on one body system at a time.

Here's what your pig should look like when you click the **skin** button **twice**.

NOTICE HOW THE
SKIN BUTTON IS
NOW FADED OUT
TO LIGHT GREY



Some Terms To Know



One More Thing!

When you see a “system button” noted in this workbook like this:

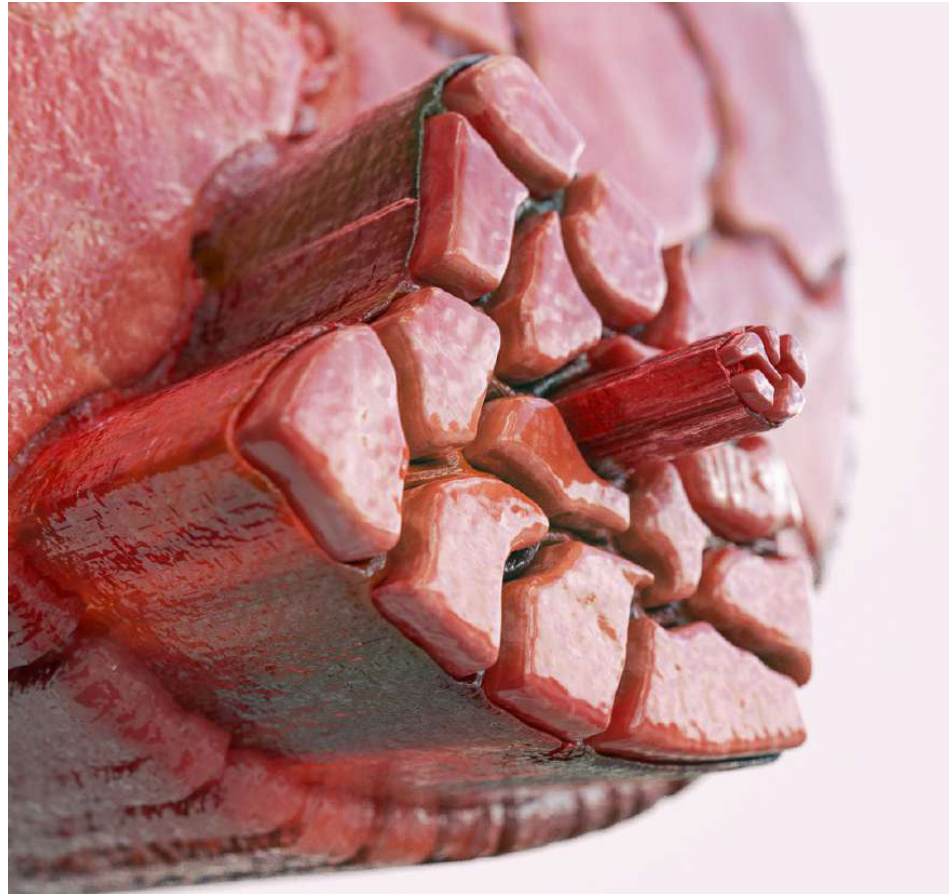


Skeleton



Respiratory

Make sure your app has the same buttons and layers showing.



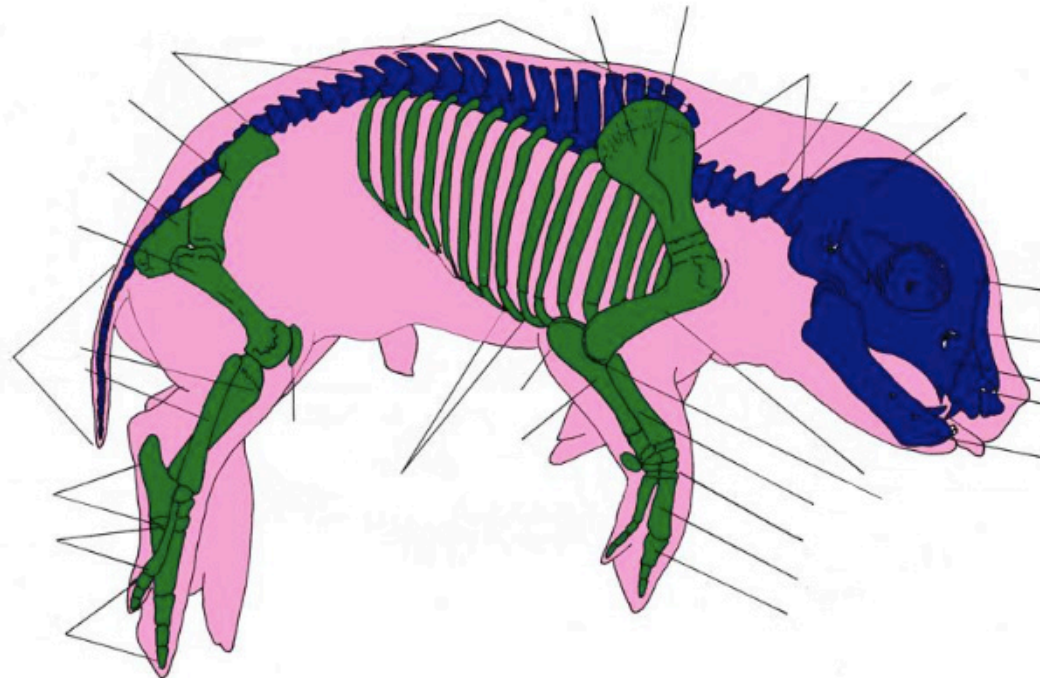
MUSCULOSKELETAL SYSTEM

TURN OFF ALL OTHER BODY SYSTEMS AND FOCUS ON THE SKELETON:

Skeleton

Bones

Use your 3D Pig Anatomy app to label all the bones on this fetal pig skeleton:

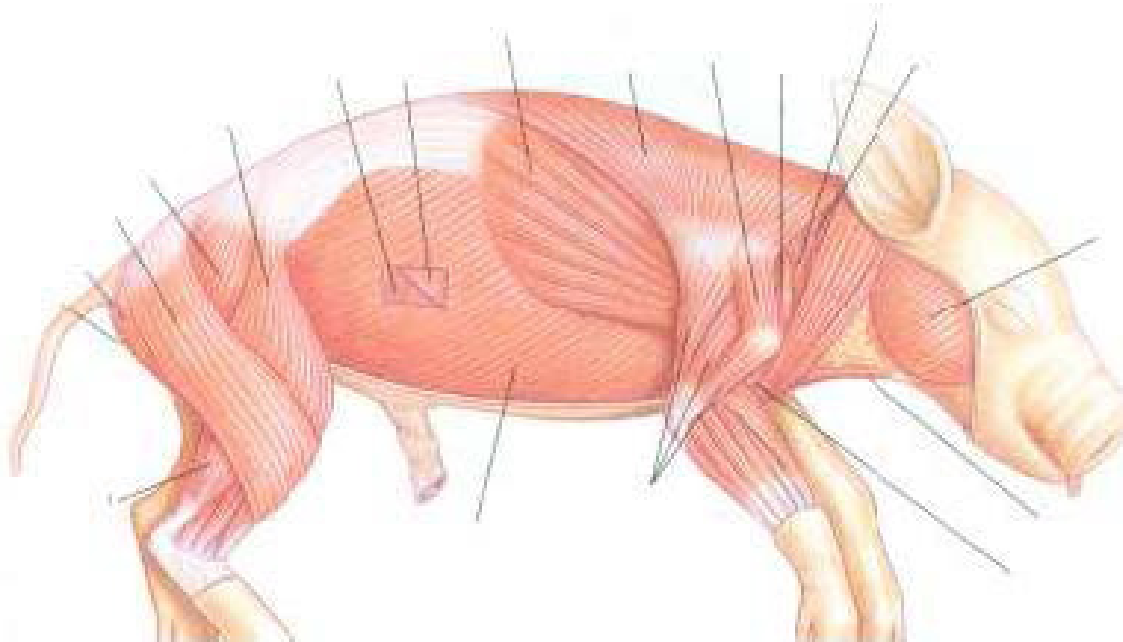


TURN OFF ALL OTHER BODY SYSTEMS AND FOCUS ON THE SKELETON:

Muscles

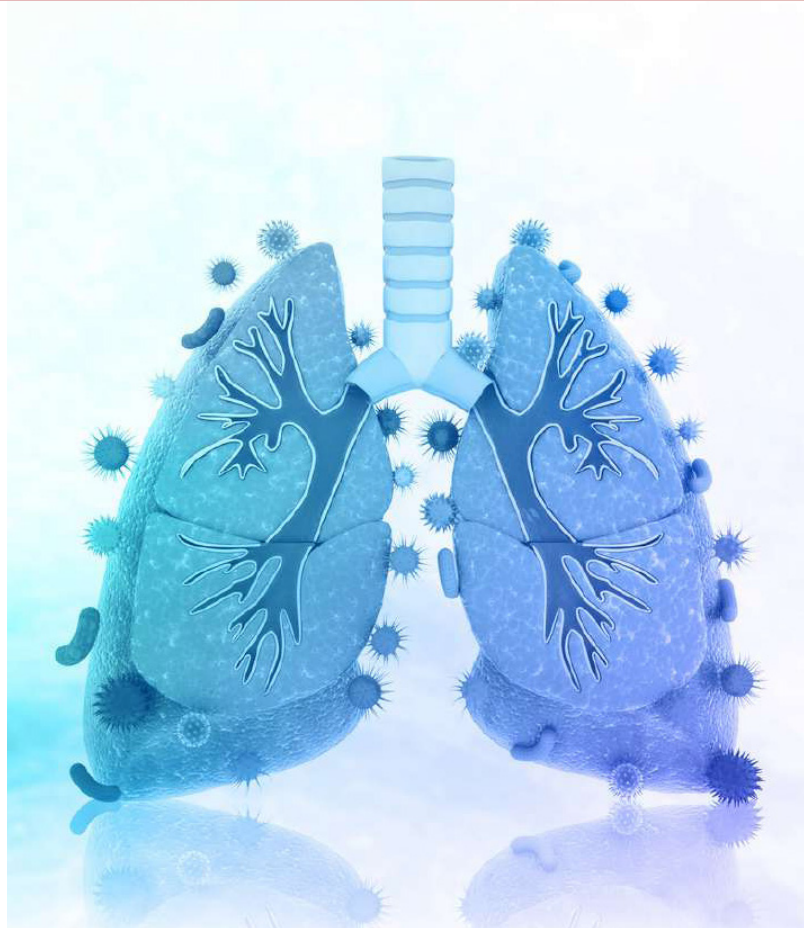
Muscles

Use your 3D Pig Anatomy app to label the muscles on the image. Feel free to peel back deeper layers and explore deeper muscles in the app!



REVIEW BREAK

With your group write down the names of three major muscles and three major bones in the musculoskeletal system of the pig.



RESPIRATORY SYSTEM

TURN OFF ALL OTHER BODY SYSTEMS AND FOCUS ON THESE:

Skeleton

Respiratory

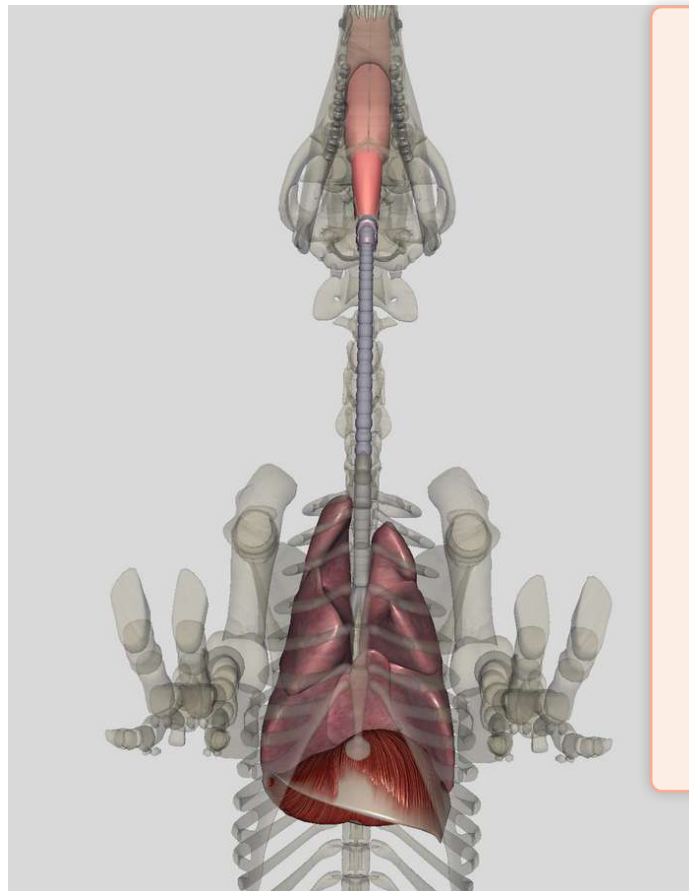
Lungs and Trachea

LUNGS

Location: chest cavity

Structure: large, spongy expandable organ

Function: the **site of gas exchange** between the respiratory and circulatory systems



Locate the **trachea** and **lungs**

Locate the **bronchi** and/or **bronchial tree**

Can you label them on the image? *Hint: to see the bronchial tree you might need to remove a respiratory system layer in the app.*

Lungs and Trachea

Why does one side of the lung have fewer lobes than the other?

The **heart** is located on the **left side**. Most animals have fewer lung lobes (including humans) on the left side of the body to **make room for the heart**.

Why would the trachea be linked with cartilage rings?

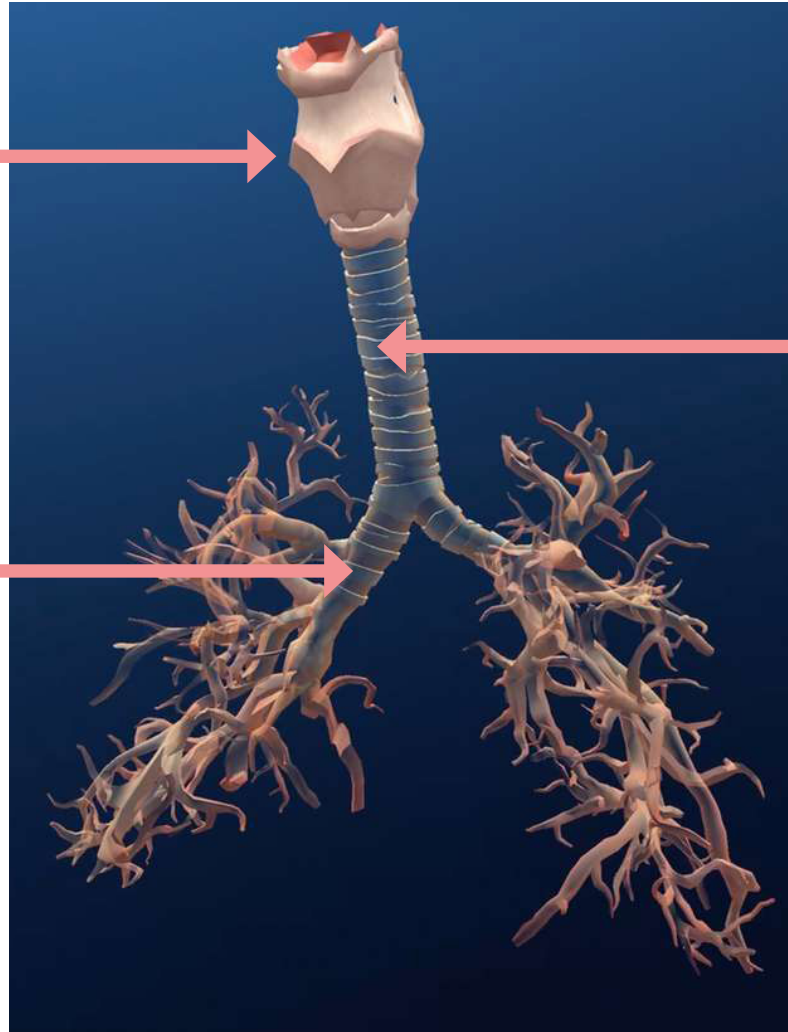
To **prevent it from collapsing** as the pig inhales.

Larynx:

Commonly called the 'voice box' the larynx is involved in breathing, producing sound, and protecting the trachea against food aspiration.

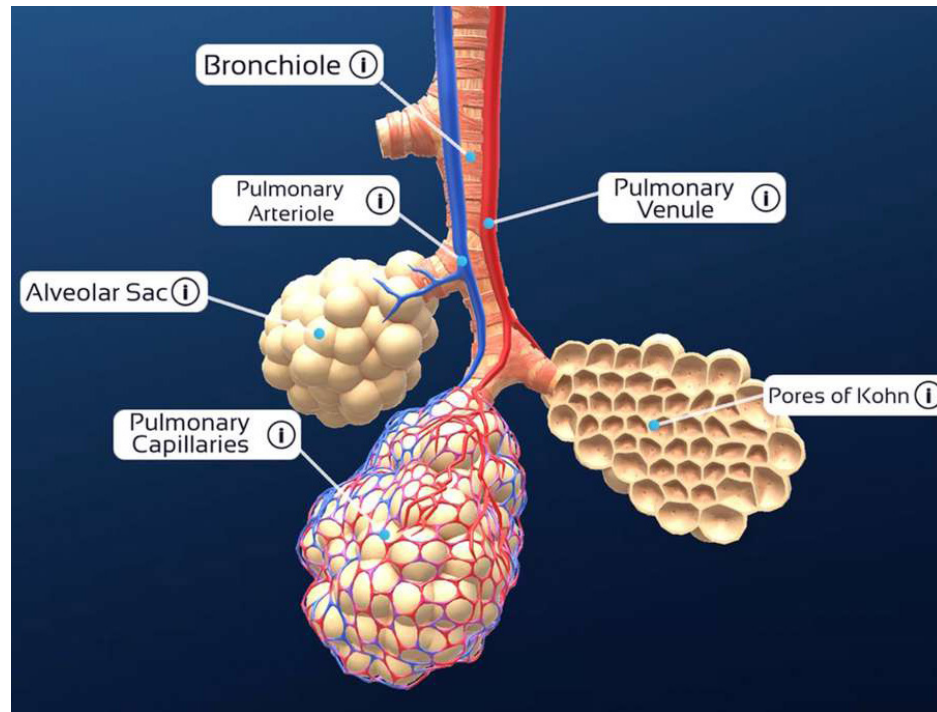
Bronchi:

Extensions of the trachea that carry air from the trachea into the lungs. There are two main bronchi that directly originate from the trachea; these main bronchi continue to branch into smaller and smaller bronchi. Each main bronchus supplies air to a single lung. While they are similar in structure to the trachea with cartilage and a mucous membrane, bronchi are also supported with a layer of smooth muscle fibres between the membrane and cartilage.



Trachea:

A cartilaginous tube that connects the pharynx and larynx to the lungs, and allows passage of air. Also known as the 'windpipe,' the trachea is a long membranous tube that is capable of lengthening and widening as air passes through. It is the largest airway of the body, and it is reinforced with 20 rings of cartilage to keep it from collapsing. The trachea moves into the lungs by branching into two separate tubes called bronchi.



An **arteriole** is a small-diameter blood vessel that extends and branches out from an artery and leads to capillaries.

A **venule** is a very small blood vessel in the microcirculation that allows blood to return from the capillary beds to drain into the larger blood vessels, the veins.

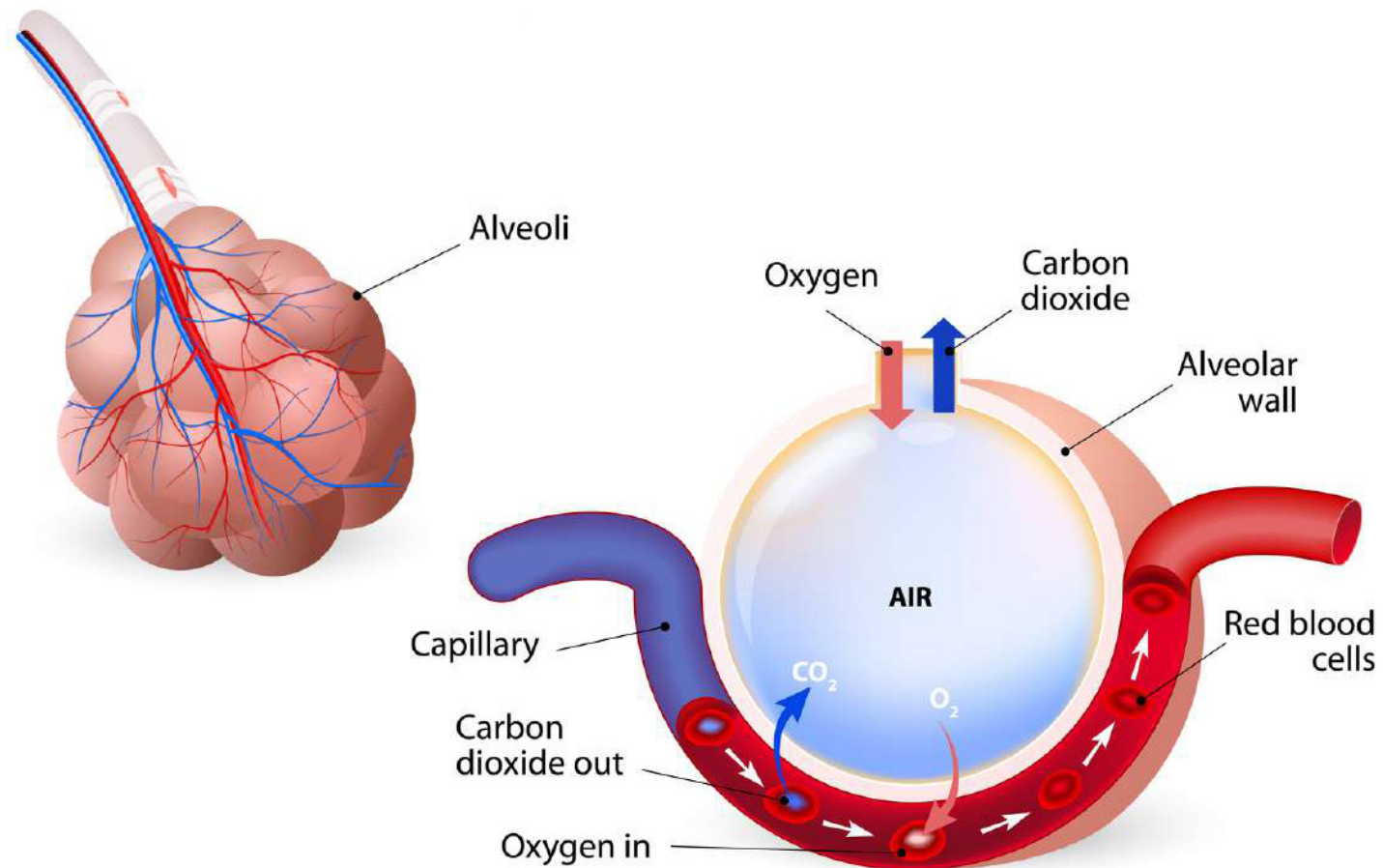
Bronchiole:

As they branch off and become smaller, bronchi eventually undergo a structural change and become bronchioles—smaller, thin-walled airways that lack cartilage and are composed of epithelial tissue cells and smooth muscle fibres. Bronchioles deliver air to little air sacs called alveoli.

Alveoli:

Terminal air sacs that are located at the end of the respiratory tree (alveolus/alveolar sac singular). Upon inhalation, the alveoli fill with air; upon exhalation, air leaves the alveoli. They are just one cell thick and lined with a fluid called a surfactant to maintain shape and surface tension, the wall of each alveolus is the site of gas exchange via diffusion. The primary function of an alveolus is to exchange oxygen and carbon dioxide to and from the bloodstream. The anatomy of an alveolus consists of an epithelial layer lining the alveolar membrane. Alveoli are further surrounded by blood vessels known as capillaries to allow oxygen and carbon dioxide to move freely between the respiratory and circulatory systems. The endothelial cells of the capillary often fuse with the epithelial cells of the alveoli to allow for rapid diffusion. Adjacent alveoli can pass air, lining fluid, and cells to each other through microscopic holes in alveolar walls called the pores of Kohn.

Gas Exchange in the Lungs



Trachea

air travels down the **trachea**, moves into each lung through the divided branches of the **bronchial tube**

Bronchial tube

↓
within the lungs, it branches further into **bronchioles**

Bronchioles

↓
tiny, thin walled sacs are on the end of the bronchioles, called **alveoli**

Alveoli

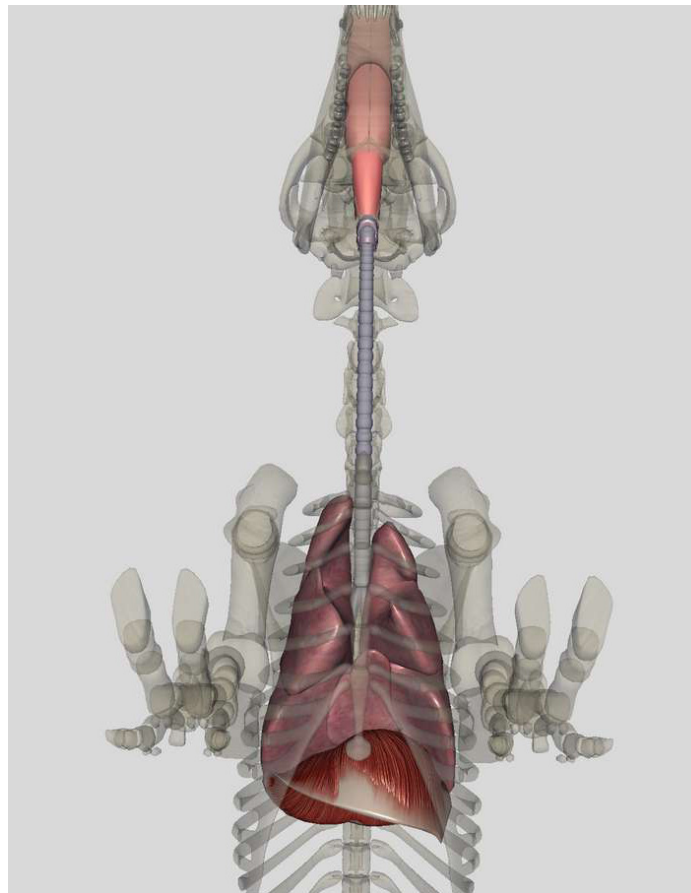
↓
site of **oxygen exchange**

Picture the branches of trees, but with thousands of little balloons on them instead of leaves!



The Diaphragm

The **diaphragm** is the layer of muscle separating the thoracic and abdominal cavity. Can you label it on the image?

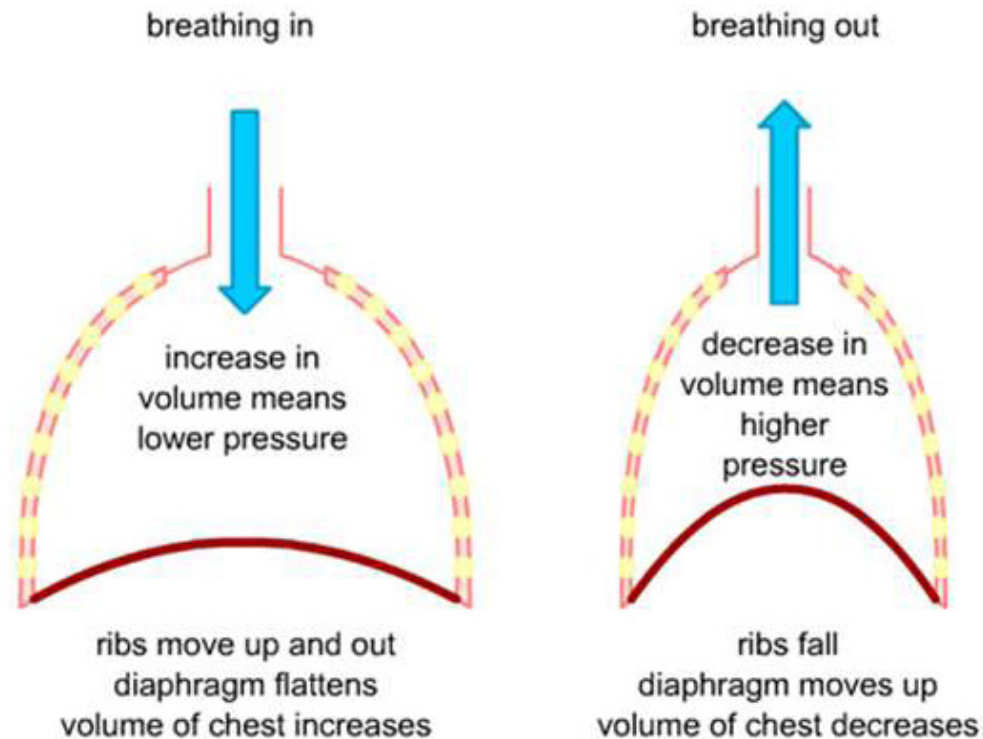


What would happen to the thoracic cavity if the diaphragm flattens?

How does this assist in breathing?

What happens during an exhale?

Most animals breath using **negative pressure** breathing.
Gases move from **high** pressure areas to **low** pressure areas.

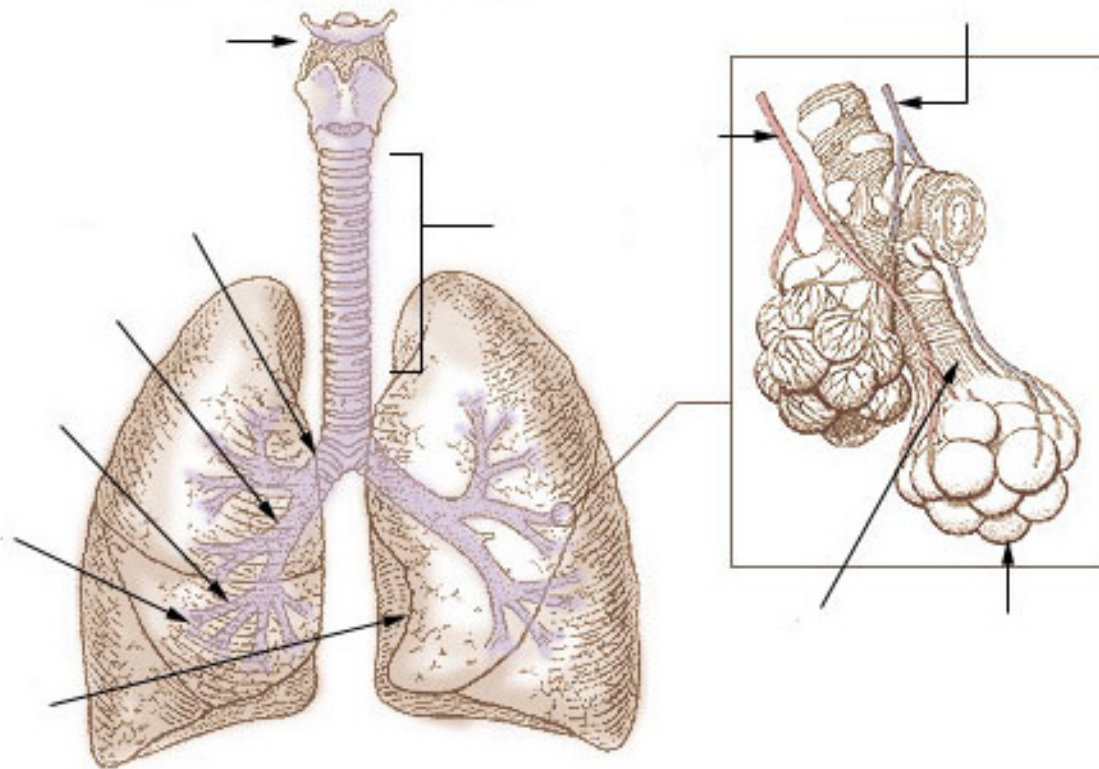


REVIEW BREAK

Have one person in your group explain to the others the mechanics of inhaling and exhaling, making sure to include negative pressure breathing. Pick someone else to explain to the others the route oxygen takes to get into our blood.

QUIZ!

Label the respiratory system diagram below





CIRCULATORY SYSTEM

TURN OFF ALL OTHER BODY SYSTEMS AND FOCUS ON THESE:

Skeleton

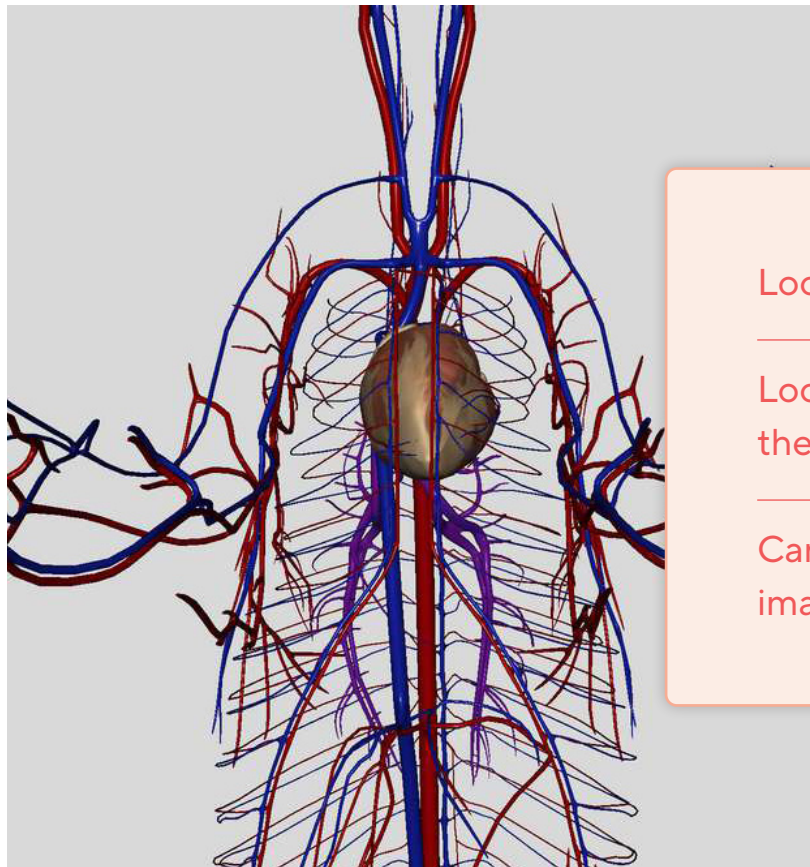
Circulatory

Heart

Location: center of the chest, nestled between the two lungs

Structure: strong muscular organ with four chambers (two atria, two ventricles)

Function: pumps **blood** to lungs and the rest of the body through strong rhythmic contractions



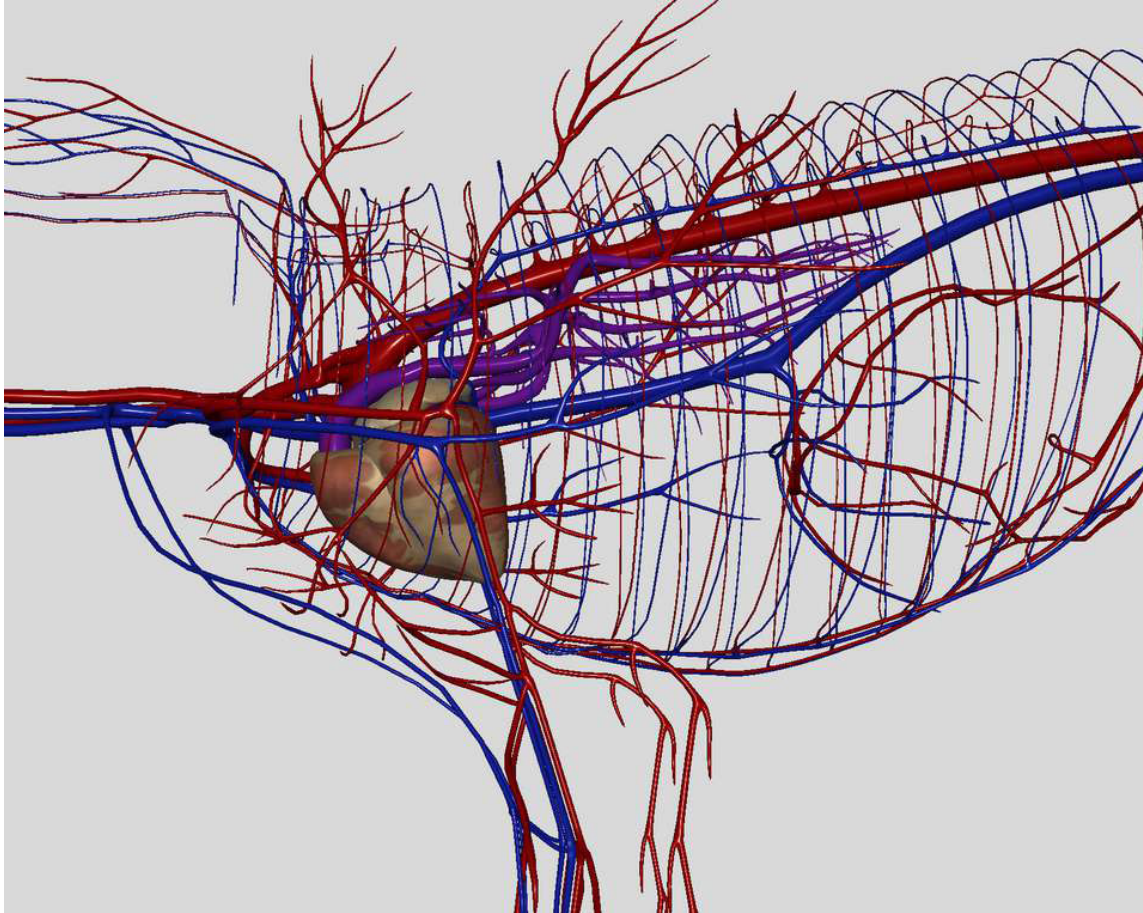
Locate the pig's **heart**.

Locate the **aorta** (red) and the **vena cava** (blue).

Can you label them on the image?

← HEAD

TAIL →

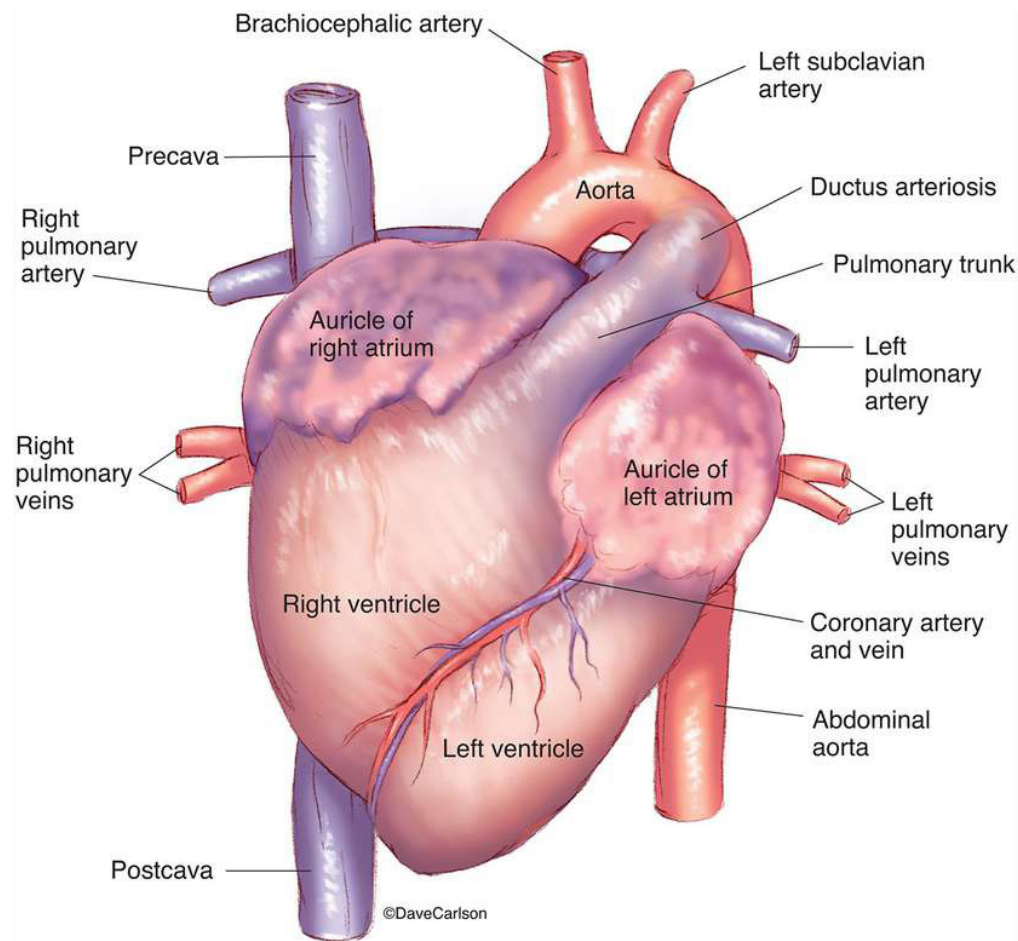


Do **arteries** always carry oxygenated blood and the veins deoxygenated blood? No, there are two exceptions, but **arteries always** carry blood away from the heart, and **veins always** carry blood towards the heart

The **pulmonary artery** and **pulmonary vein** are the exceptions. Can you locate them and label them on the image?

Hint: You'll need to rotate your pig so that they are sideways, and you can click through the circulatory system layers in the app to get a better look at the veins and arteries.

Heart



Bloodflow Through the Heart

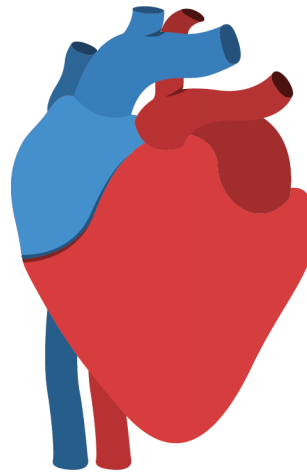
The caudal, inferior and superior vena cava vessels carry **deoxygenated** blood to the right **atrium**.



Blood is then pumped from the right atrium to the **ventricle**.



Blood is pumped from the right ventricle out to the **pulmonary arteries**, which carry the blood to the lungs to receive oxygen.



The left ventricle pumps oxygenated blood out to the body via the aorta.



Blood is then pumped from the left atrium to the ventricle.



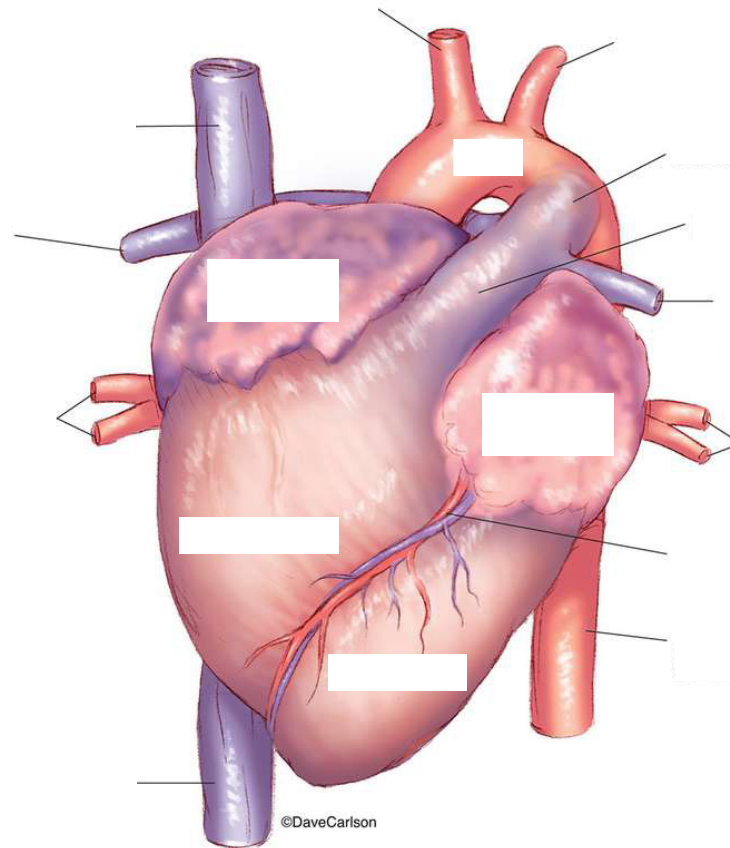
Pulmonary veins carry oxygenated blood back to the heart and into the **left atrium**.

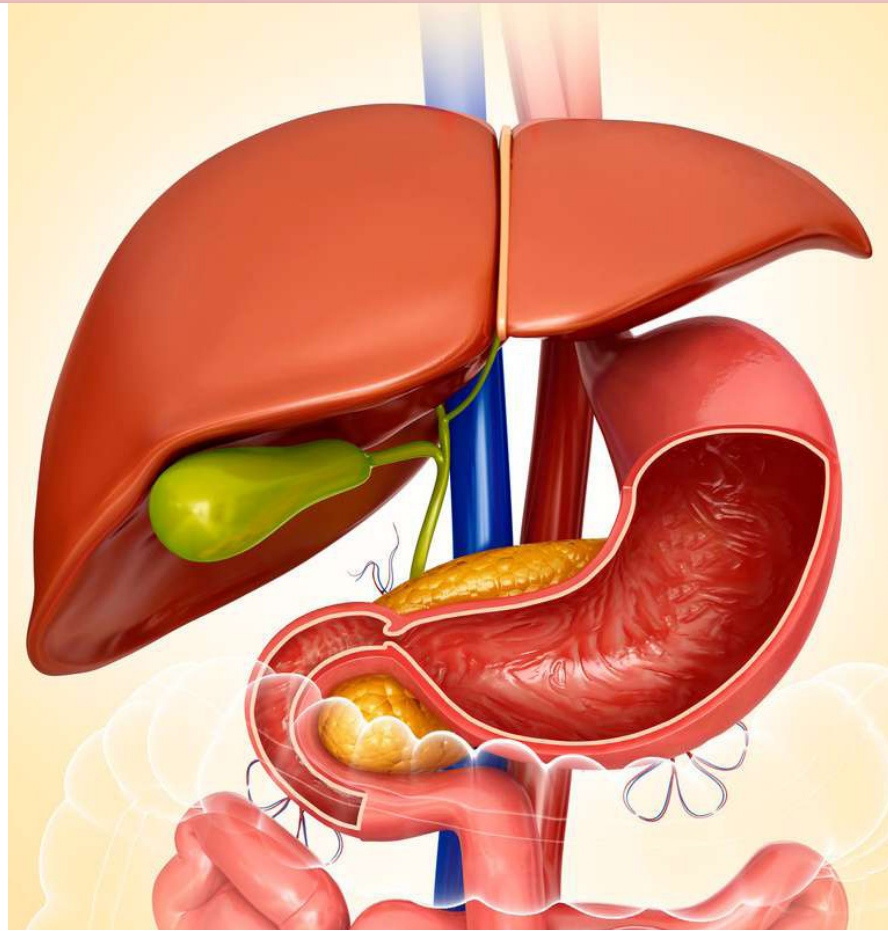
REVIEW BREAK

With your group, trace the path of blood as it flows through the heart, to the lungs, and back again.
Choose one person to explain it to the class.

QUIZ!

Without looking back through your workbook, label the heart diagram below.





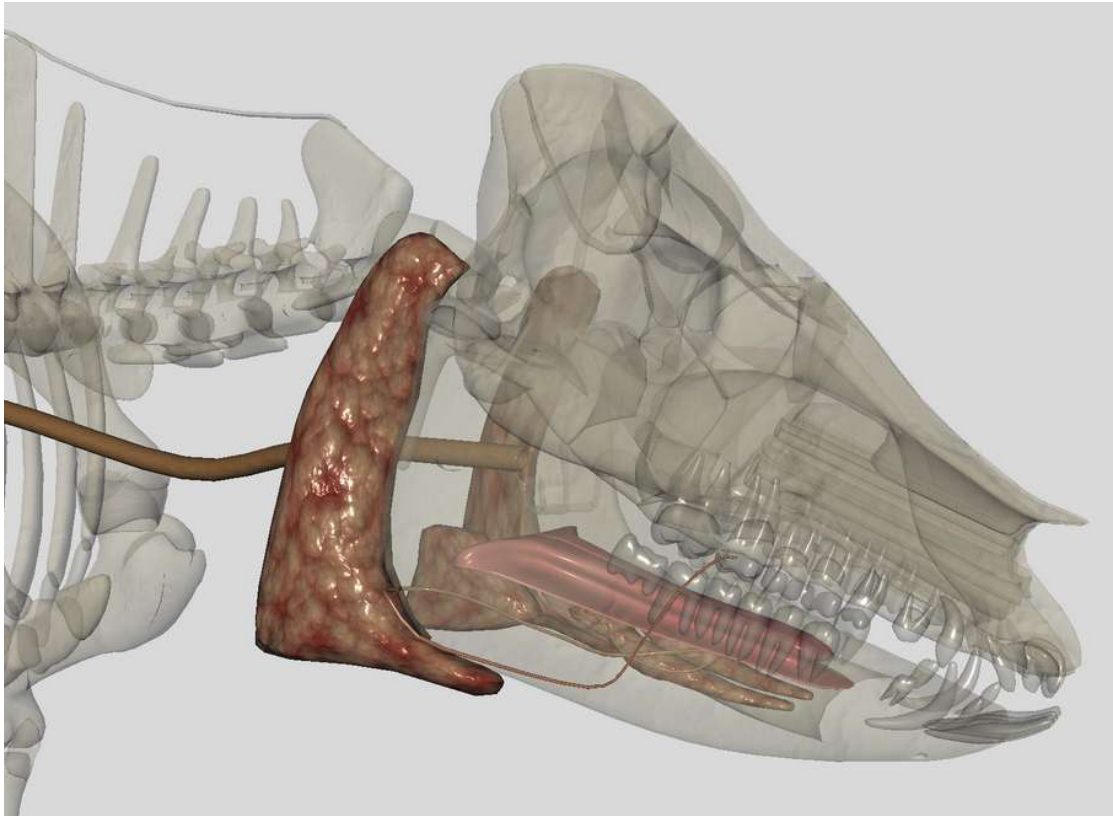
DIGESTIVE SYSTEM

TURN OFF ALL OTHER BODY SYSTEMS AND FOCUS ON THESE:

Skeleton

Digestive

Digestive System: External Anatomy



Rotate your pig and zoom in so that the head is visible.

Hover your pointer over the **teeth** to show the labels.

Can you label the image?

Teeth



Molars: teeth furthest back in mammalian jaw. Usually adapted for grinding and tearing food

Incisors: forward-most teeth in mammalian jaw. Usually adapted for obtaining food by cutting or cropping

Canines: similar to incisors, mainly tear and rip food

Many **mammals** have evolved highly specialized type of teeth.

BASED ON THIS COMBINATION OF TEETH, WHAT DO YOU THINK ARE THE DIETARY HABITS OF A PIG?



Carnivore



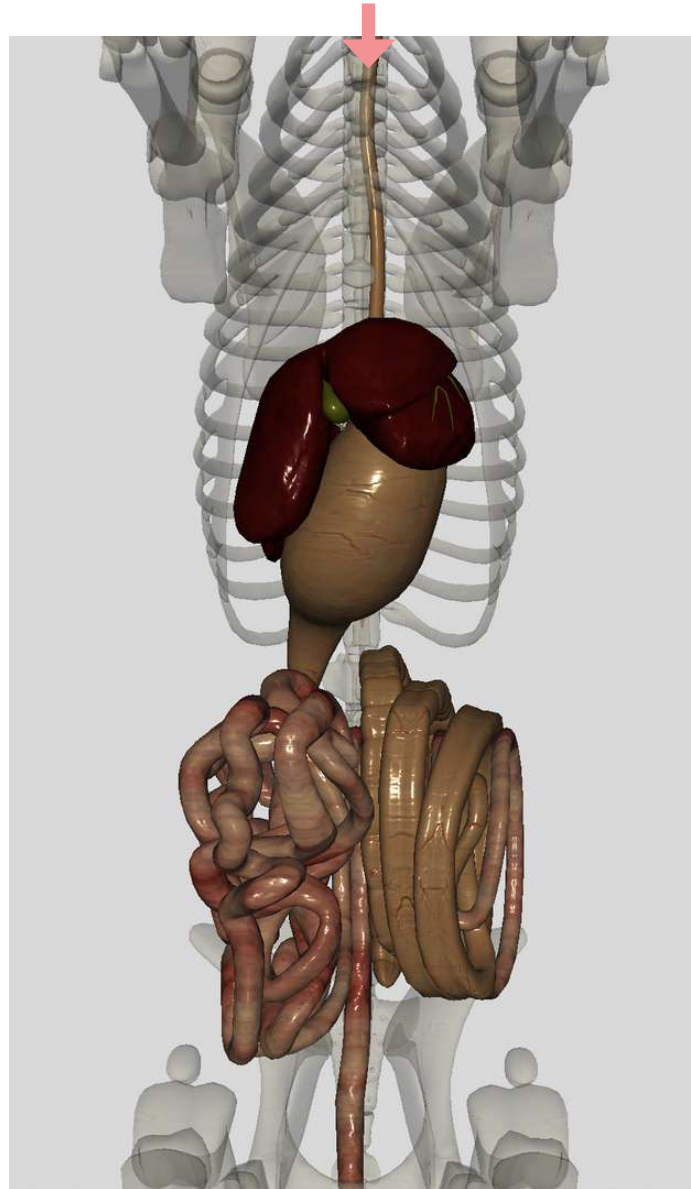
Omnivore



Herbivore

Normal diet consists of a variety of plant and animal material

Food travels
down **esophagus**
towards **stomach**.



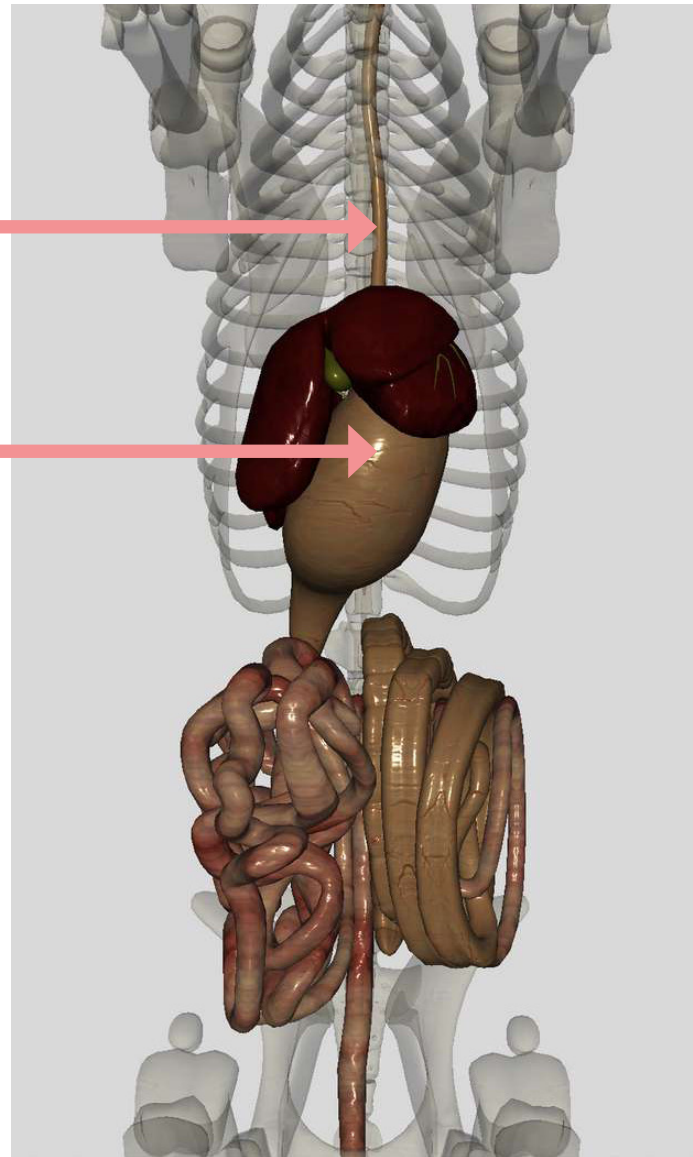
Rotate your pig so you are
looking at the **ventral** view
(put your pig on their back),
zoom in as needed.

After mechanical and
chemical digestion in the
mouth, the chewed food
(called a **bolus**) is swallowed.

The bolus then enters
the **esophagus**. Muscle
contractions called
peristalsis push food along
towards the stomach.

esophagus

stomach



The bolus moves through the esophagus to the **anterior portion** of the stomach.

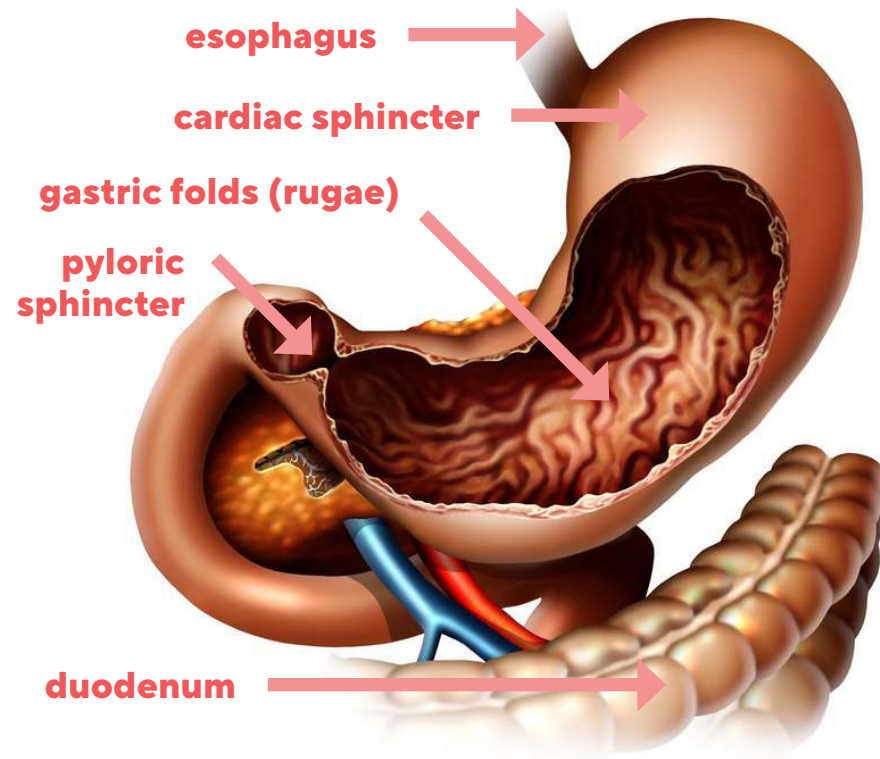
Stomach

Location: dorsal and posterior to the liver

Structure: muscular organ

Function: muscular organ that continues the chemical and mechanical digestion that started in the mouth

Pyloric Sphincter: Valve between the stomach and duodenum (first part of small intestine)



Three types of stomach cells:

Mucus cells: secrete protective coat

Parietal cells: secrete HCl (pH 3) that kill bacteria and help breakdown food

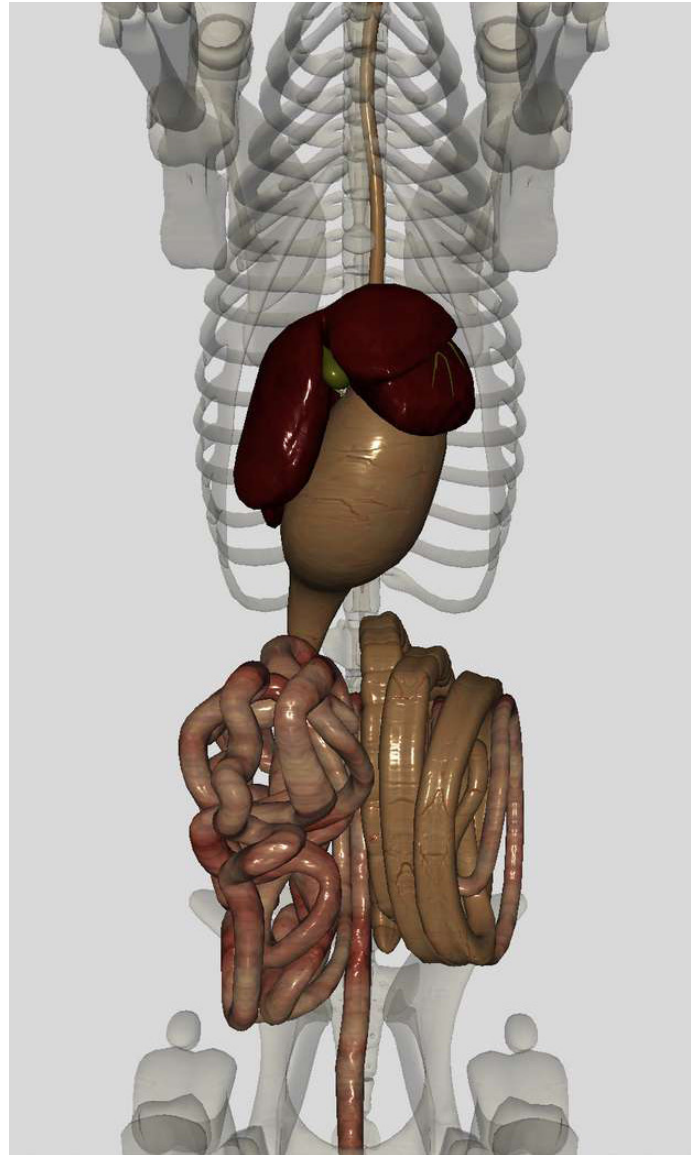
Peptic cells: secrete pepsinogen, which forms the enzyme pepsin when combined with HCl

Pepsin is a hydrolytic enzyme that breaks down proteins into smaller amino acid chains called peptides. Peptides are broken down into individual amino acids further on in digestive system by other enzymes.

Protein + H₂O → Pepsin → Peptides

Why doesn't the stomach digest itself?

- A mucus layer prevents the HCl from eating through
- Pepsin could digest protein in the stomach cells, but pepsin is inactive until it mixes with HCl
- HCl isn't formed until it crosses the stomach lining



The food travels to the **small intestines** from the **stomach** through the **pyloric sphincter**.

Locate and label the **jejunum** and **ileum**. These, along with **duodenum** make up the small intestines.

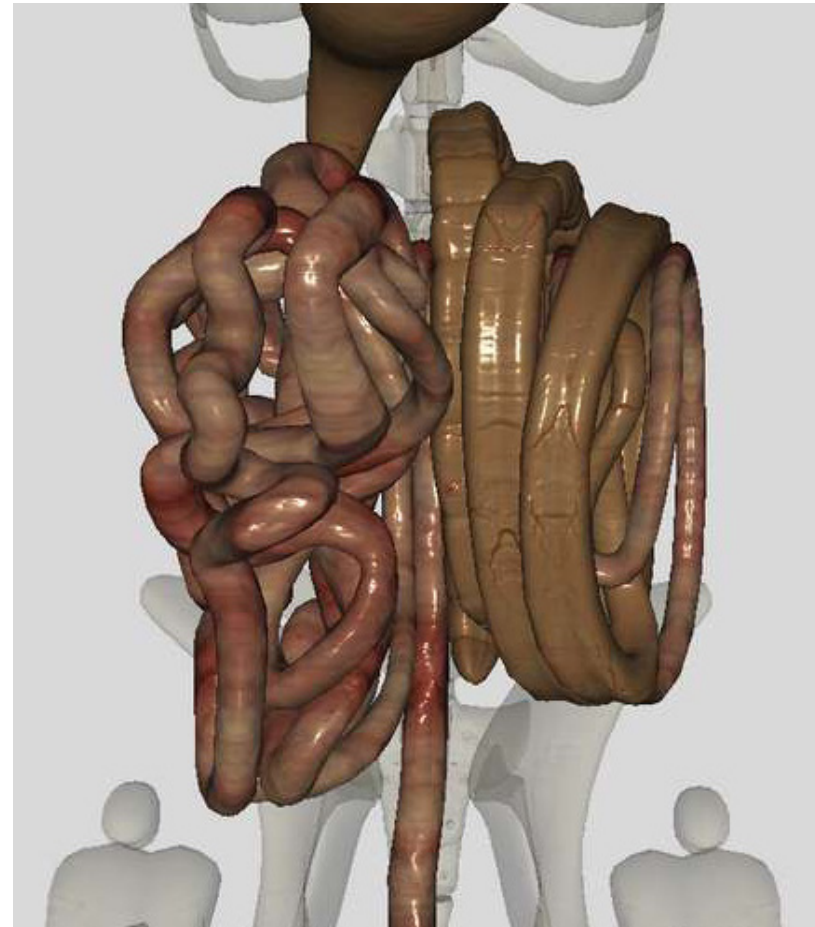
Can you label them on the image?

Small Intestine

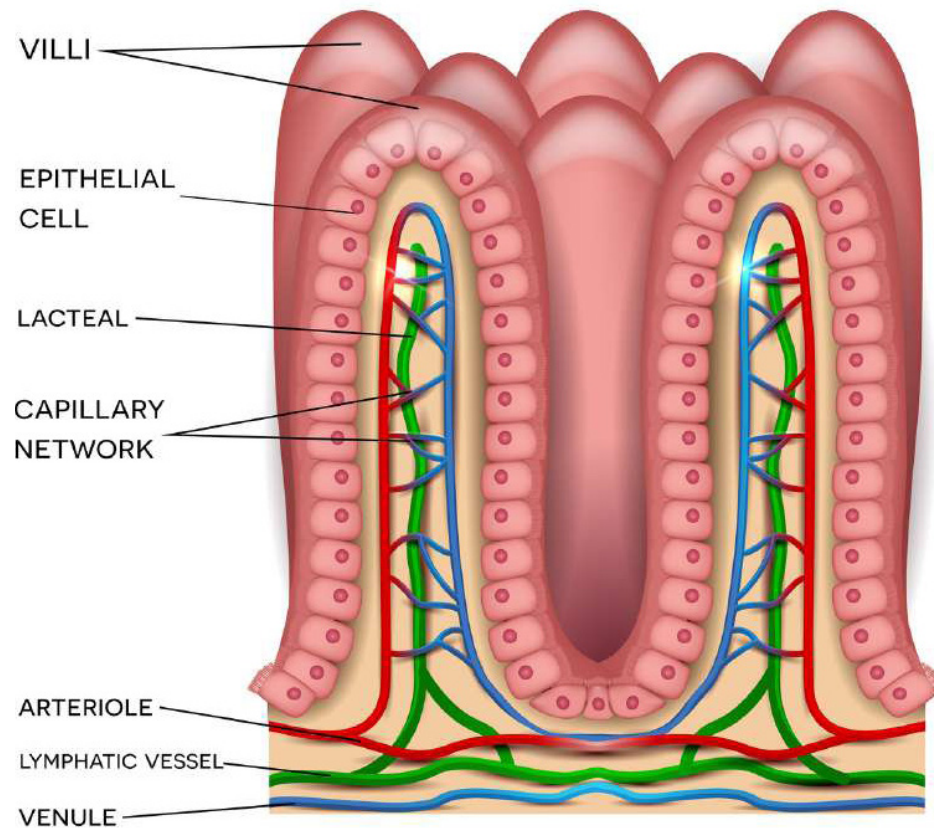
Location: slender coiled tube, starting at the **stomach**, and connects to the **large intestine** at the **caecum**

Structure: consists of **duodenum**, **jejunum**, and **ileum**, supported and wrapped by a membrane of **mesentery**

Function: receives food from stomach and completes **digestion** started earlier—most food **absorption** and **chemical** digestion occurs here



Intestinal Villi



What lines the internal surface of the small intestine and what is its function?

Villi: Increase absorptive surface of the small intestine; higher surface area means more area for absorption

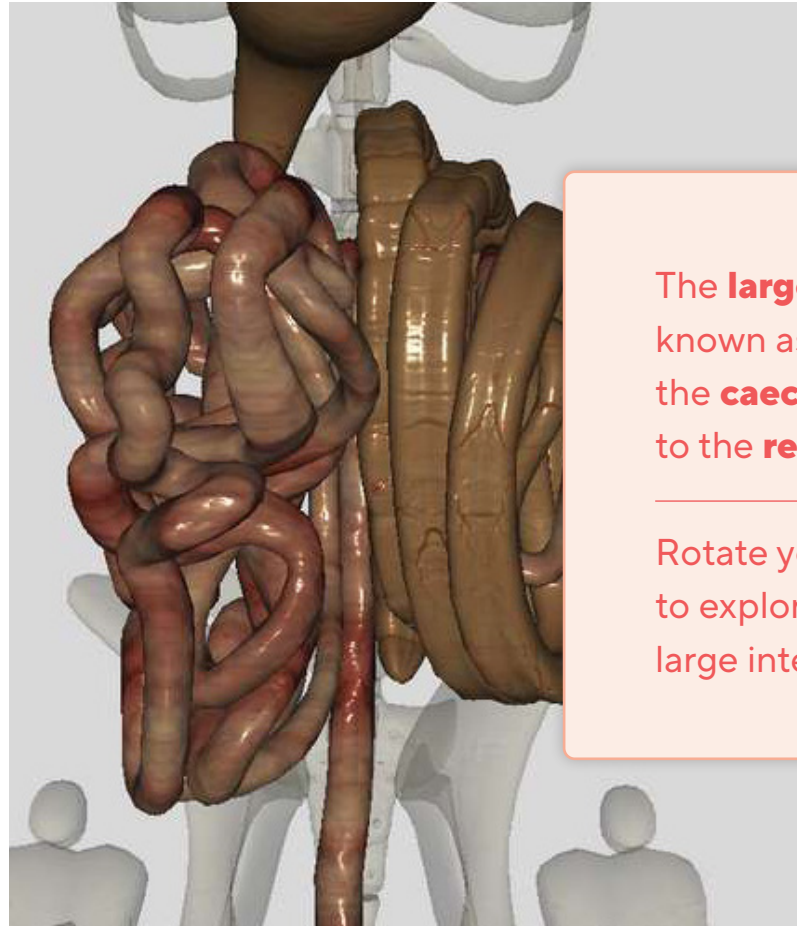
** You won't see villi on the 3D Pig Anatomy app, but they are there!*

Large Intestine

Structure: consists of descending **colon** and **rectum** (*muscular contractions in large intestine initiate defecation*)

Function: storage of undigested materials that have passed through the small intestine (*reabsorbs water from food*)

Caecum contains microorganisms which help breakdown plant material not digested by enzymes in small intestine.



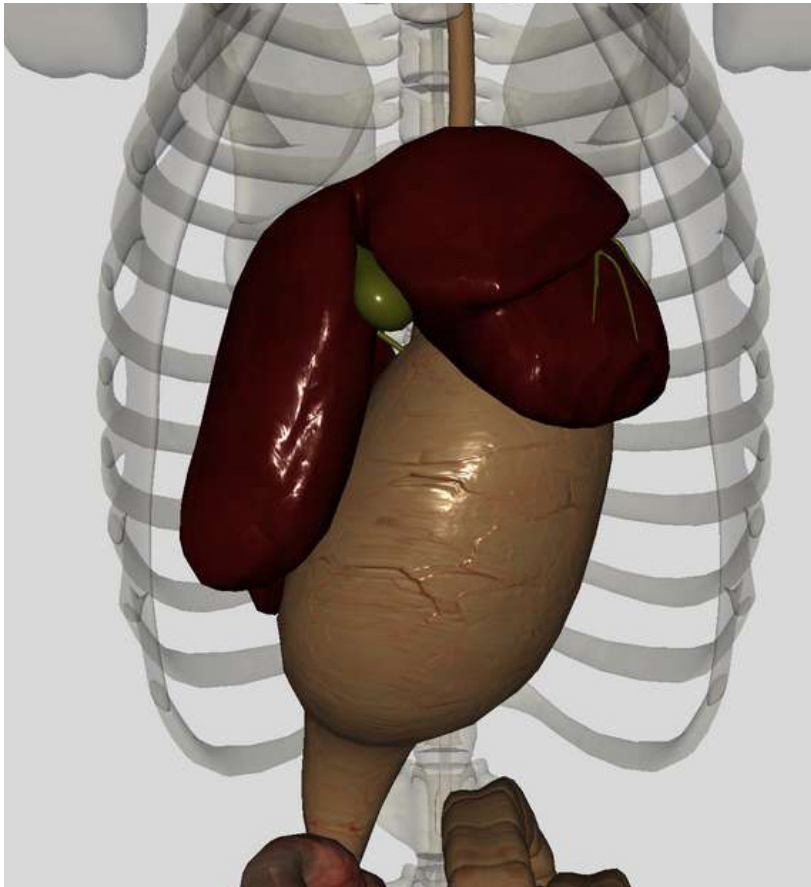
The **large intestine** (also known as **colon**) starts at the **caecum** and connects to the **rectum**.

Rotate your pig as needed to explore the caecum and large intestine (colon).

WHY WOULD SOME CARNIVORES HAVE A VERY SMALL OR SOMETIMES NON-EXISTENT CAECUM?

1. Since these animals do not consume plant matter, the caecum is unnecessary.
2. The caecum of herbivores is much larger than the caecum of omnivores.
3. These animals consume more cellulose and water, making a larger caecum necessary for effective digestion.

Liver



Location: ventral and anterior to the **stomach**

Structure: dark red/brown wedge-shaped organ with **four lobes**

Function: multipurpose organ

Produces bile, removes toxins, stores carbs, and regulates blood sugar levels.

Pancreas

EXOCRINE FUNCTIONS:

Cell secretions released into a duct

Produces bicarbonate ions (HCO_3^-).

- These neutralize stomach acids and make pH of intestine 7–8 (alkaline).
- Are released through pancreatic duct. Small intestine enzymes are optimum at basic pH.

Produces digestive enzymes:

amylases, peptidases, lipases, and nucleases, which are released through pancreatic duct into the small intestine.

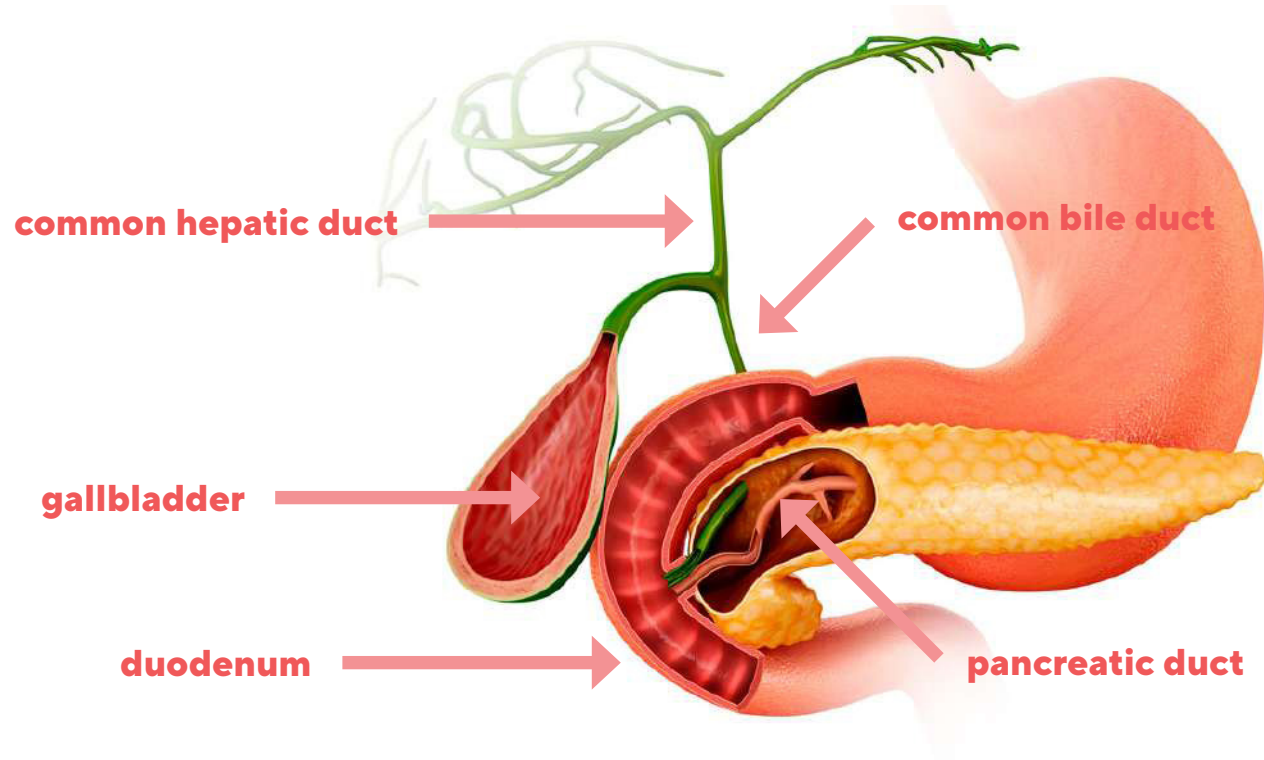
ENDOCRINE FUNCTIONS:

Cell secretions released into blood

Produces insulin: controls cellular uptake of glucose and its conversion into glycogen (insulin secreted when low glucose levels in blood).

Produces glucagon: stimulates conversion of glycogen into glucose (glucagon secreted when high glucose levels detected in blood)

Regulates blood sugar.



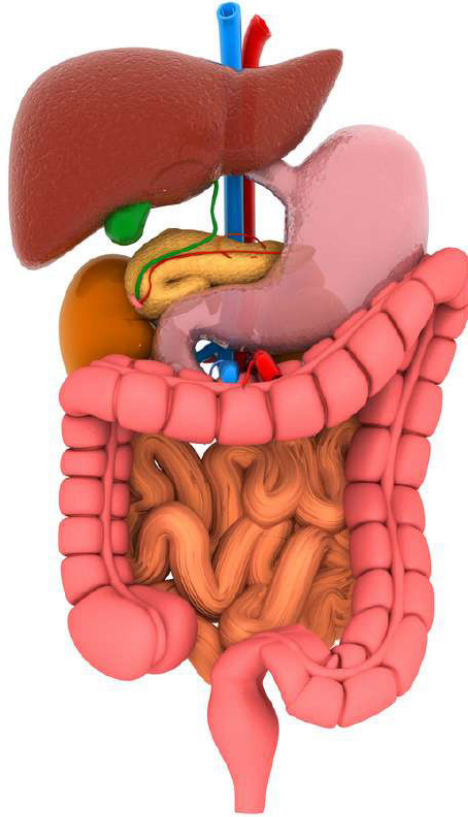
Just after eating **high glucose** level food, **insulin** is secreted which causes cells to take up glucose in the liver and muscle. Glucose is then converted into **glycogen** for storage. When fasting, glucagon converts glycogen in the liver and muscle into glucose.

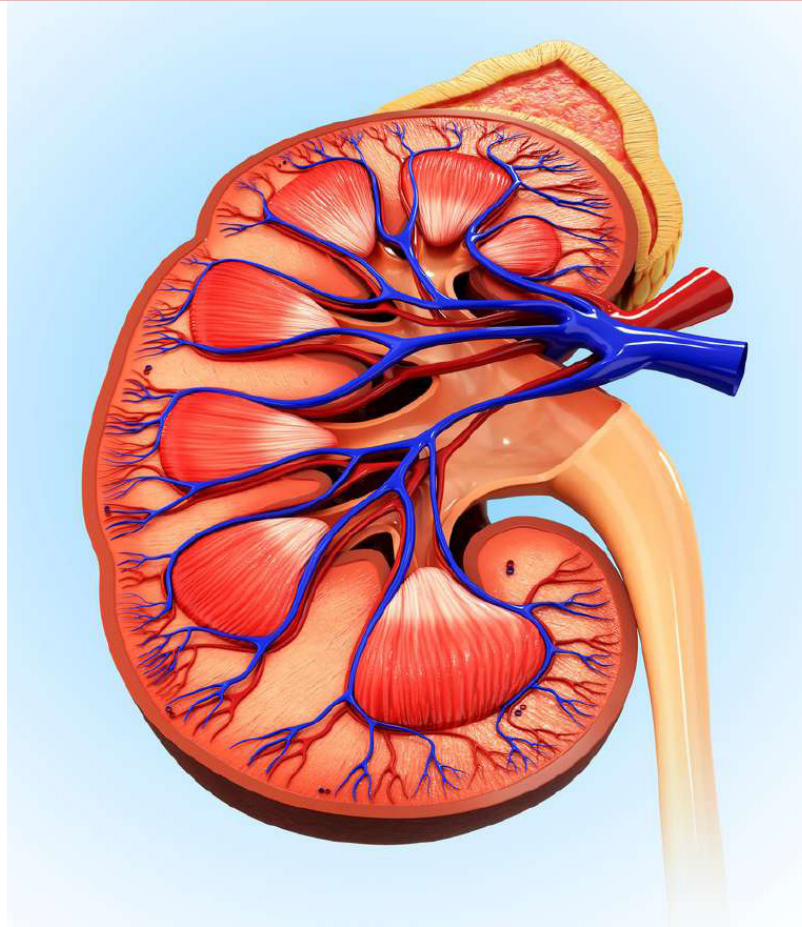
REVIEW BREAK

With your group, trace the path of food through the digestive system. Name all the different structures the food passes through from the moment a pig takes a bite, to the moment it poops! Choose one person to explain it to the class.

QUIZ!

Without looking back through your workbook, label the digestive system diagram below.





URINARY SYSTEM

SEE ENDOCRINE SYSTEM FOR DETAILS OF REPRODUCTIVE ORGANS

TURN OFF ALL OTHER BODY SYSTEMS AND FOCUS ON THESE:

Skeleton

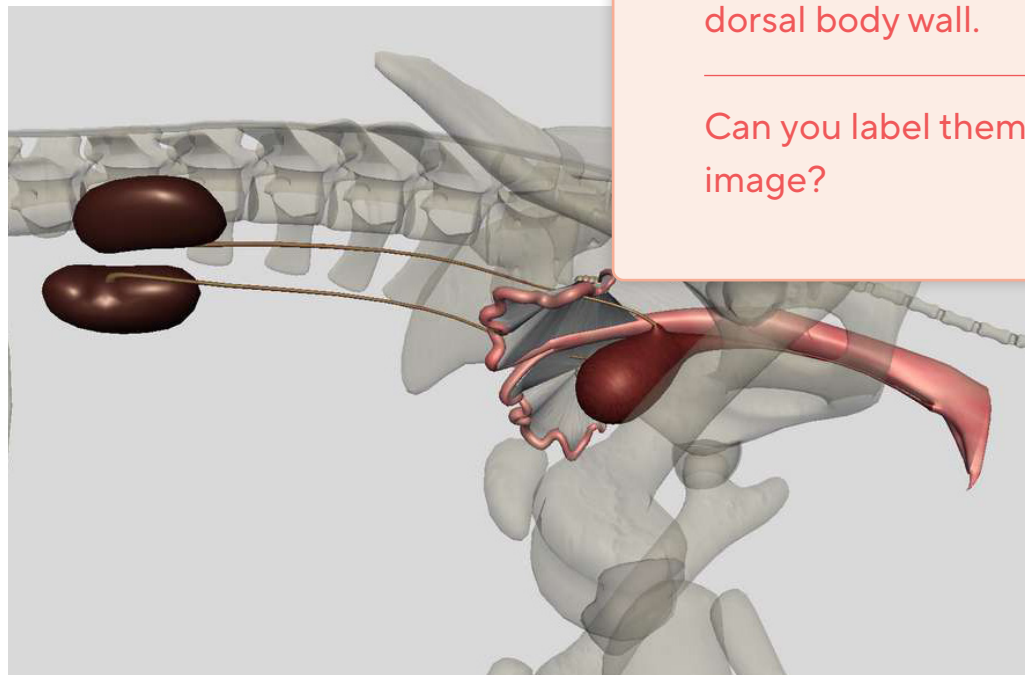
Urogenital

Kidneys

Location: high in abdominal cavity, one on each side of the spine

Structure: bean-shaped, surrounded by tough fibrous tissue

Function: removes **nitrogenous wastes** (eg. urea/urine) from the blood and **maintains osmolality** (salt balance) in blood



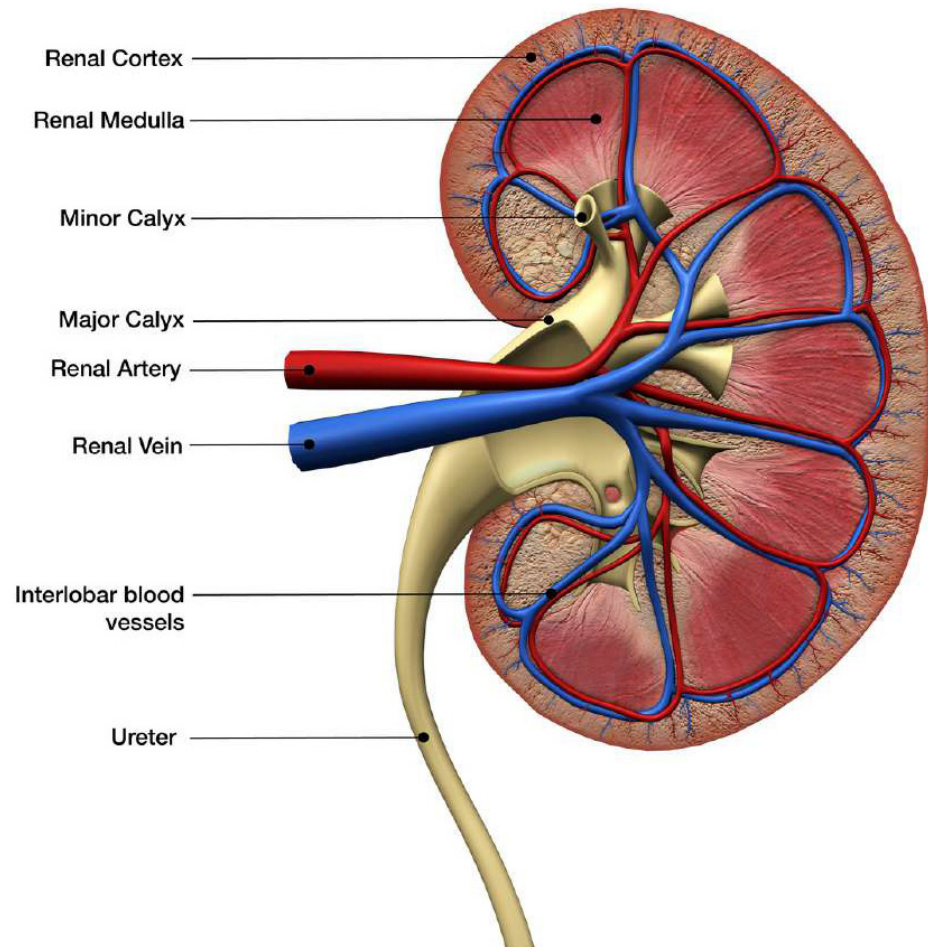
Locate the **kidneys** found embedded in the fat in the dorsal body wall.

Can you label them on the image?

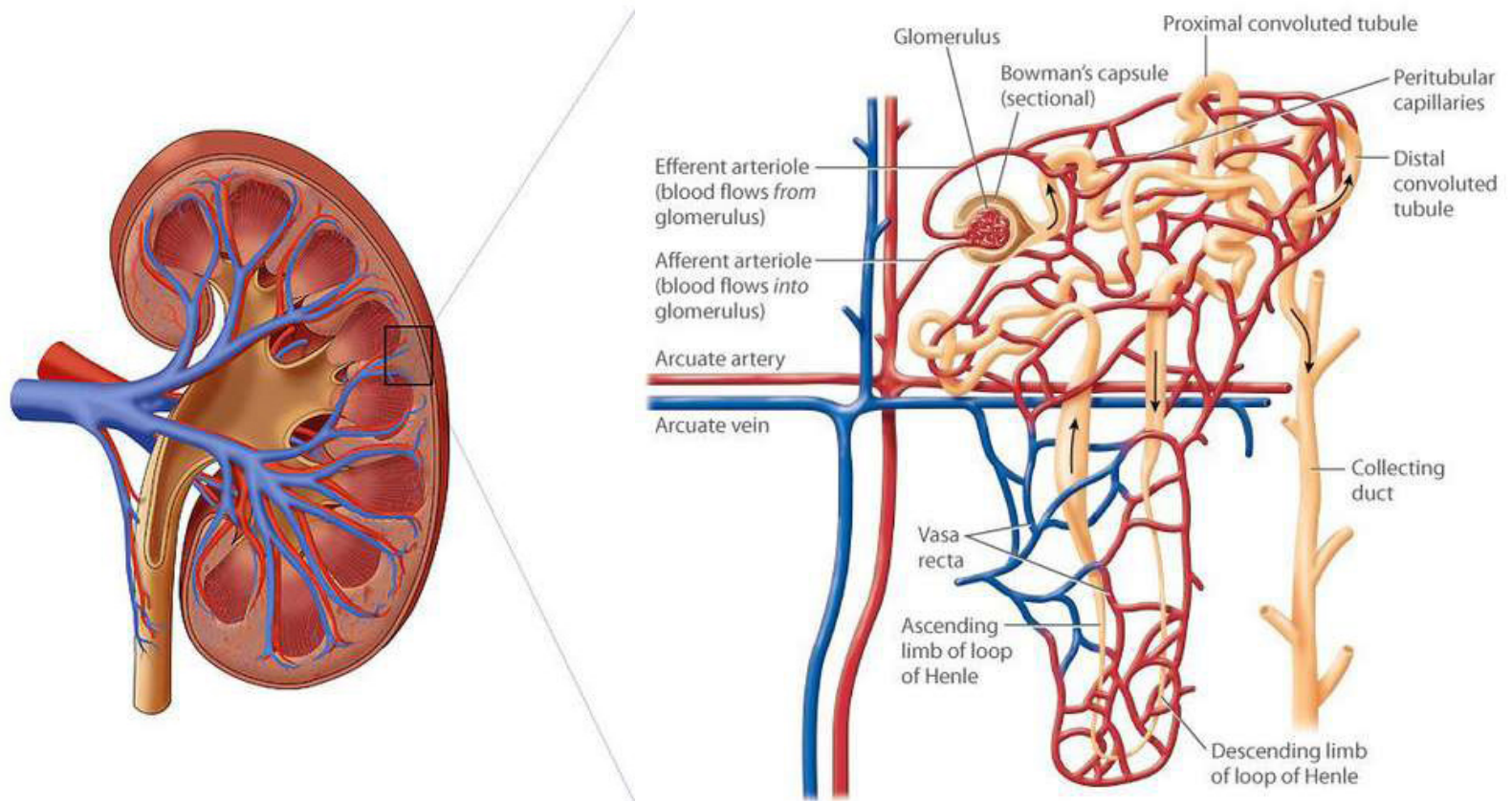
Kidney Function

Kidneys are chief regulators of the body's internal environment, and therefore perform several **homeostatic functions**:

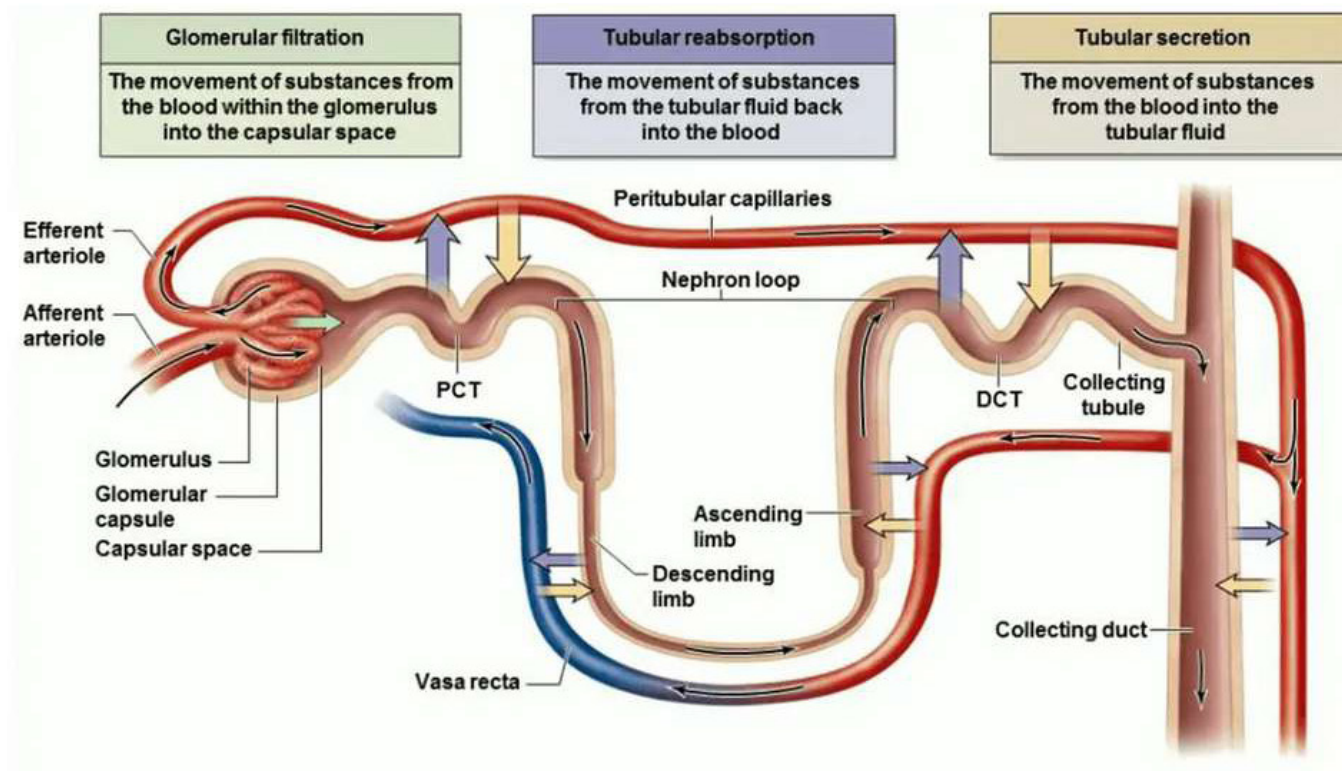
- **Regulate osmotic balance and blood volume** by conserving or excreting H_2O as demanded by the situation
- **Regulate ion concentration** between the extracellular fluid (ECF) and the blood by controlling the excretion of inorganic **salts**
- **Regulate blood pH by excreting excess bases or acids:**
 - » H^+ is excreted and HCO_3^- is reabsorbed if **blood is acidic**
 - » H^+ is NOT excreted and HCO_3^- is NOT reabsorbed if **blood is basic**
- **Excretes toxic metabolic by-products** like **urea**, ammonia, uric acid, and creatinine



The **nephron** is the functional unit of the kidney. It consists of a renal tubule and its associated blood vessels.

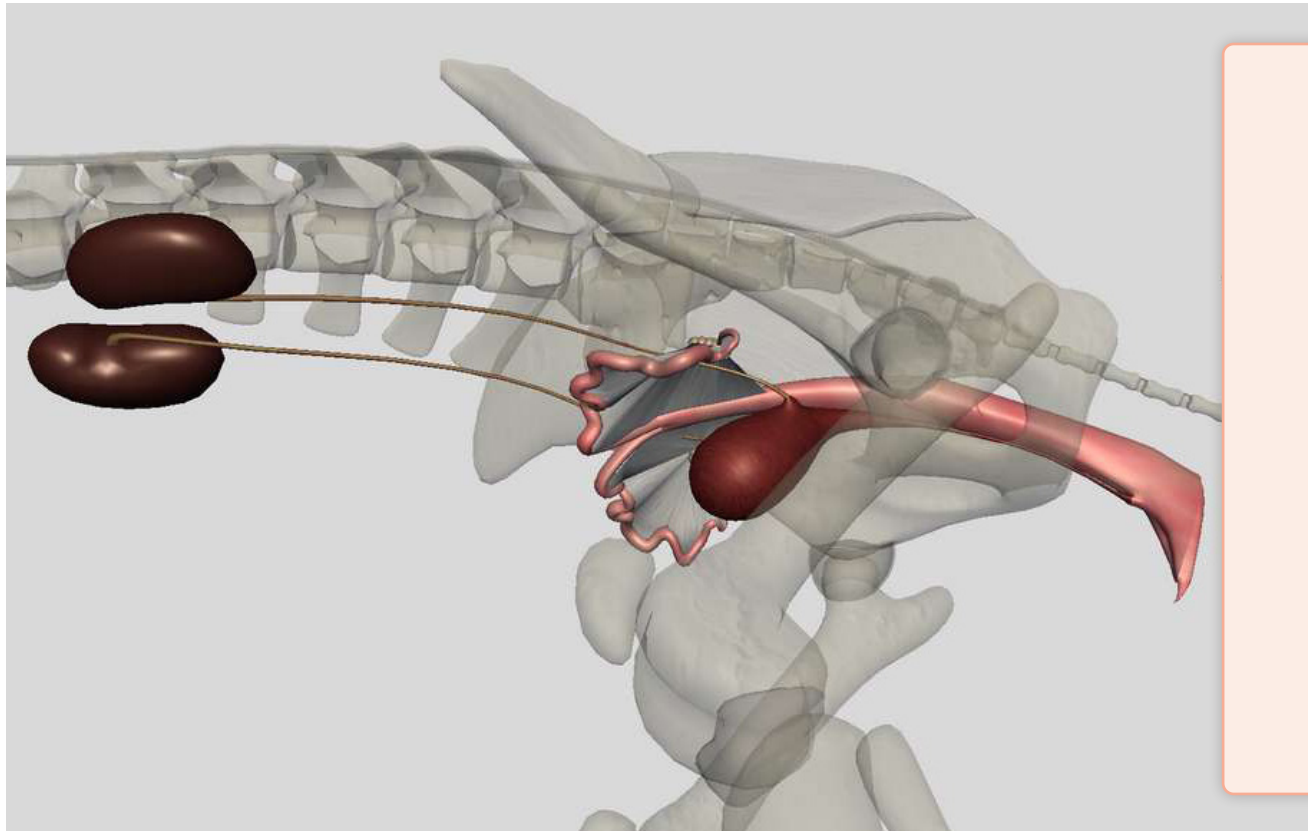


Urinary Formation



Check Your Understanding: Make sure you can explain what the main processes are that occur during each stage of urine formation.

Ureter and Urinary Bladder



Locate the **ureter** and **urinary bladder**. Also locate the **urethra**.

Can you label them on the image?

Change the sex of the pig. Why do you think the female and male **urethras** are different?

Ureter

Location: a vessel running between the **kidneys** and the **urinary bladder**

Structure: thin tube

Function: **carries** excretory products produced by the **kidneys**

Urinary Bladder

Location: connected to the **ureter** and **urethra**

Structure: sac-like structure

Function: **stores** urine produced by **kidneys** and releases it into the **urethra**

FEMALE:

Location: duct runs between the urinary bladder and urethral opening

Function: tube carrying urine from the bladder to the outside of the body

MALE:

Location: duct runs between urinary bladder through the most distal part of the penis to the urethral opening

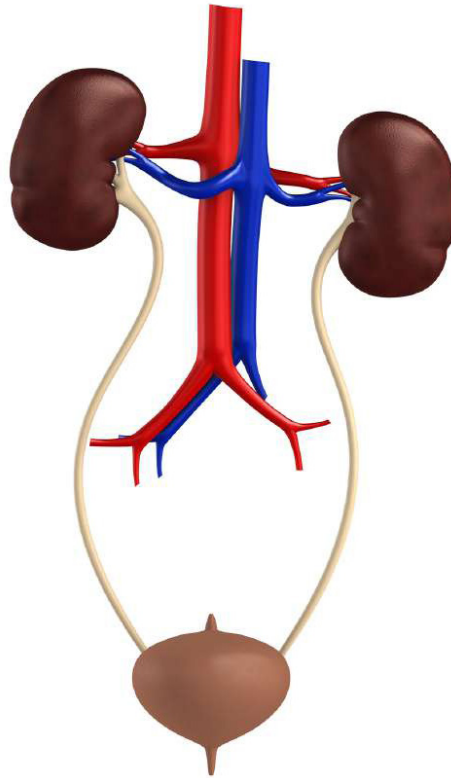
Function: tube carrying urine and sperm to the outside of the body)

REVIEW BREAK

With your group, explain the formation and the path of urine from the kidneys to the outside of the body. Choose one person to explain it to the class.

QUIZ!

Without looking back through your workbook, label the urinary system diagram below.





NERVOUS SYSTEM

TURN OFF ALL OTHER BODY SYSTEMS AND FOCUS ON THESE:

Skeleton

Nervous

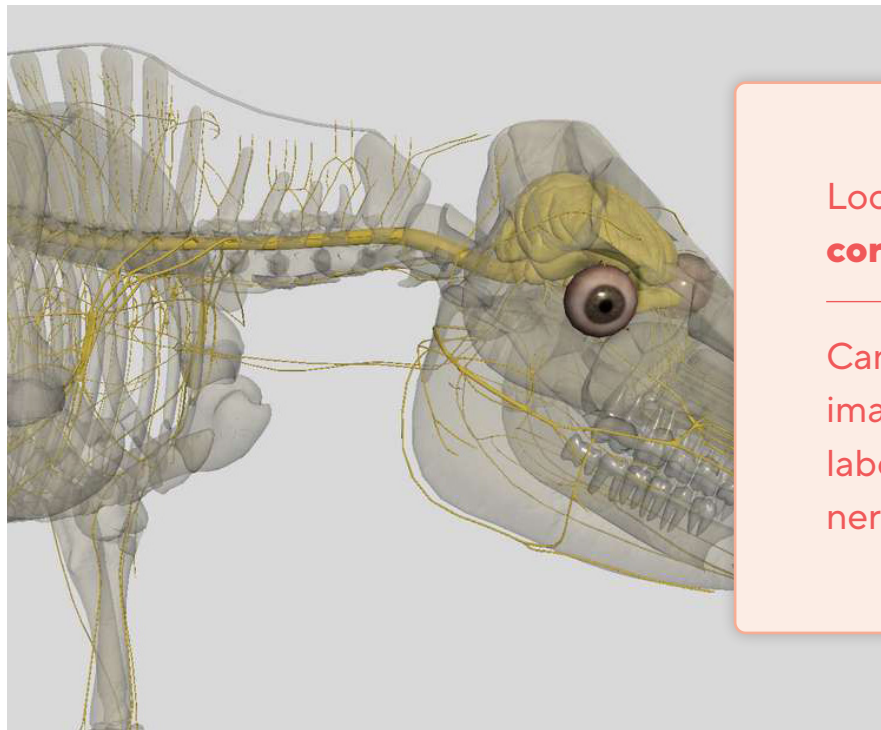
Central Nervous System

BRAIN

Location: in the skull

Structure: about the size of a peanut, smooth surface, packed with neurons

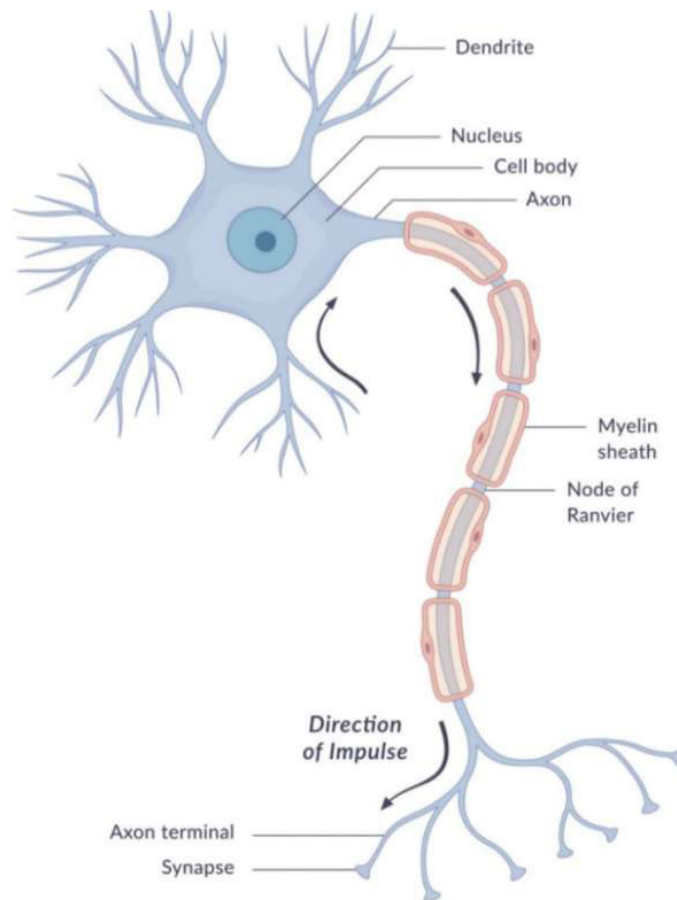
Function: the pig's **central information processor**



Locate the **brain** and **spinal cord**.

Can you label them on the image? Use the app to label more features of the nervous system!

Nerves



Nerves are bundles of **neurons** (like the one pictured to the left) that transmit electrical “nerve impulses.” Nerve impulses are part of a special information system in the body. For example, when you touch something warm with your hand, the nerves in your hand transmit the information about temperature to your brain, which then translates that into your feeling of “warmth” in your hand.

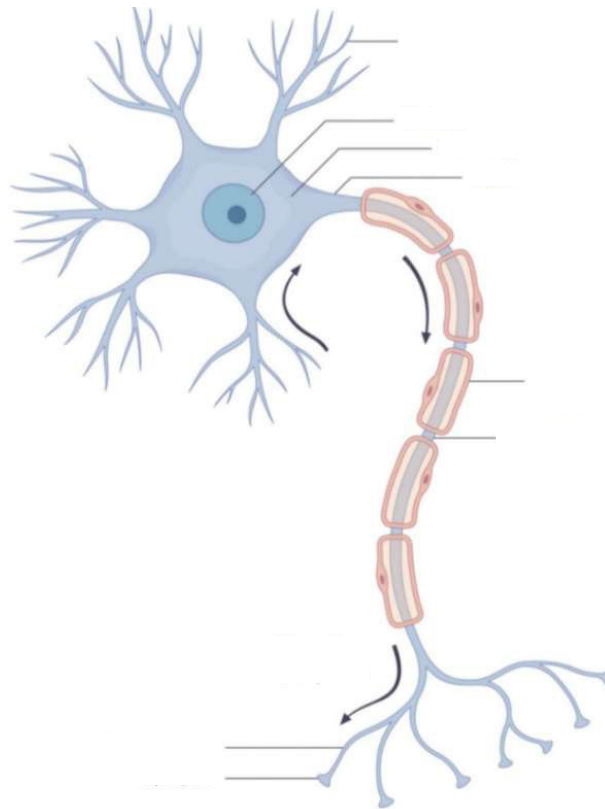
REVIEW BREAK

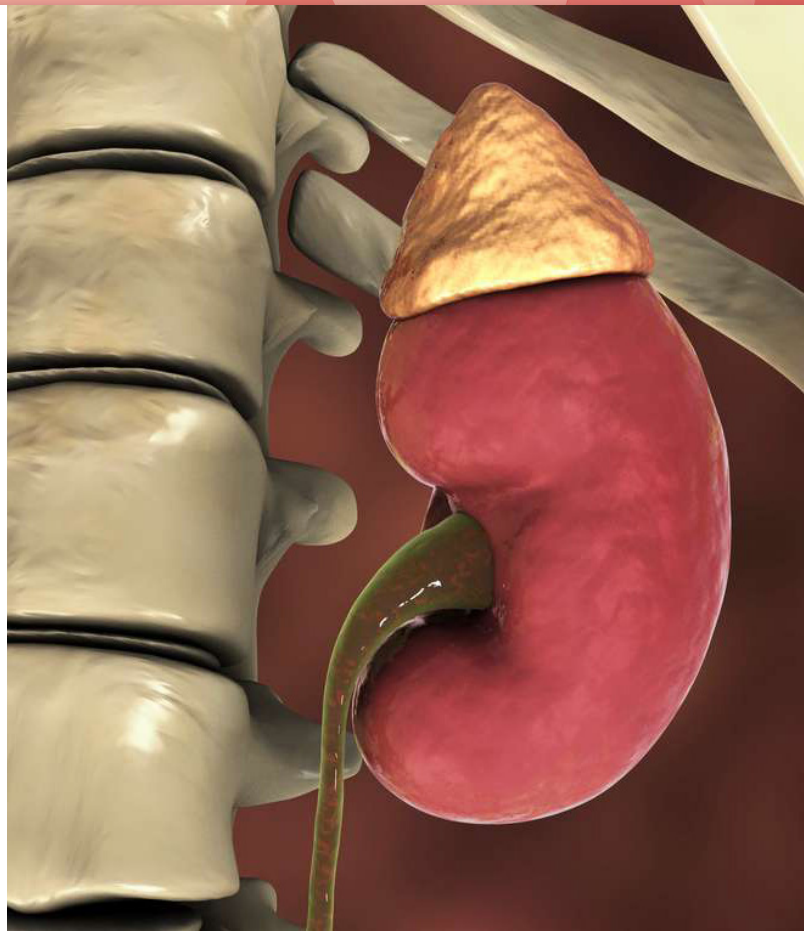
With your group, try to draw the major features of the pig nervous system—include the brain, spinal cord, and some nerves. Can you name some of the nerves?

With your group, draw a single nerve cell (neuron). Try to label it. Choose one person to explain these to the class.

QUIZ!

Without looking back through your workbook, label the urinary system diagram below.





ENDOCRINE SYSTEM

TURN OFF ALL OTHER BODY SYSTEMS AND FOCUS ON THESE:

Skeleton

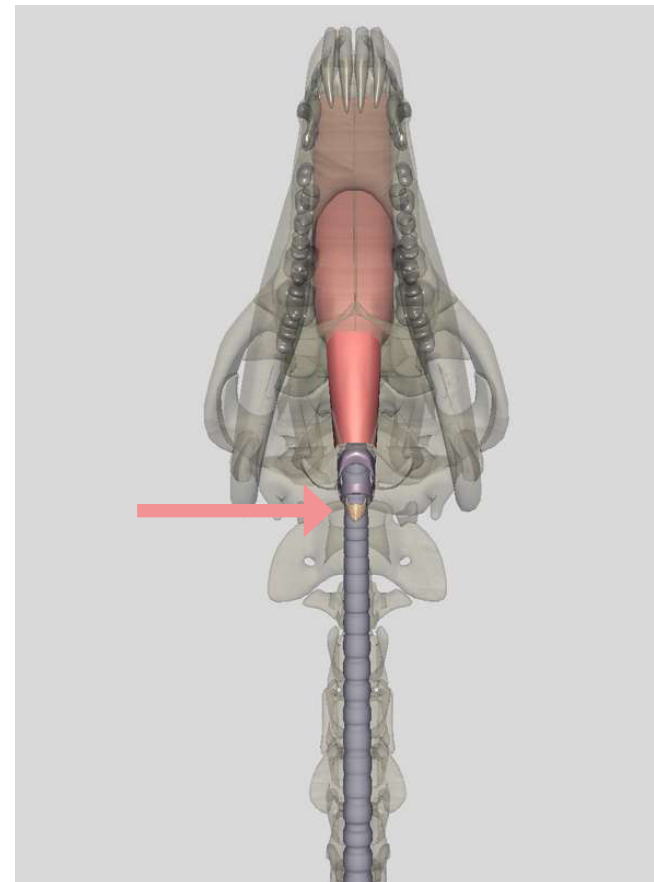
Respiratory

Endocrine

Thyroid

Location: around the trachea in the throat area

Function: produces hormones that **regulate the body's metabolic rate** **controlling heart**, muscle and digestive function, brain development and bone maintenance



TURN OFF ALL OTHER BODY SYSTEMS AND FOCUS ON THESE:

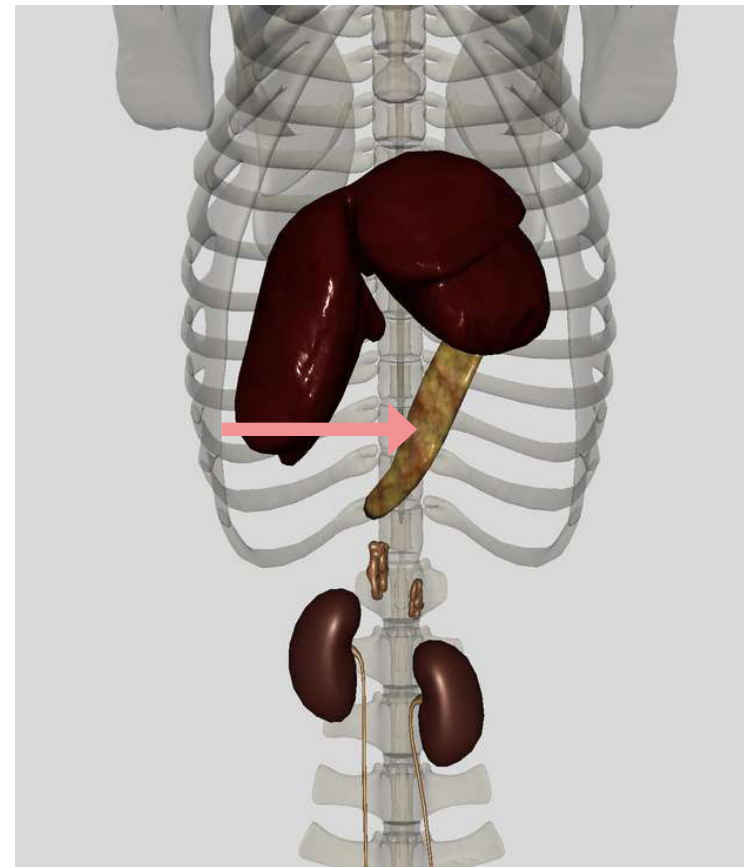
Skeleton

Endocrine

Pancreas

Location: near stomach in abdominal cavity

Function: produces **insulin** (which reduces blood sugar) and **glucagon** (which increases blood sugar)



TURN OFF ALL OTHER BODY SYSTEMS AND FOCUS ON THESE:

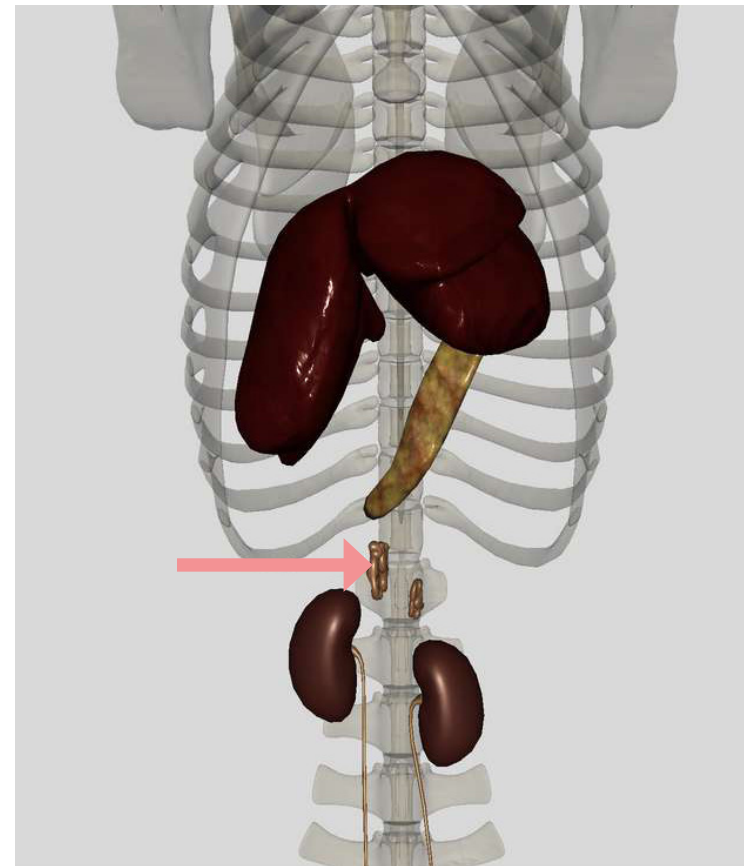
Skeleton

Endocrine

Adrenal Glands

Location: anterior end of kidneys

Function: produce **adrenaline** and **corticosterone** (the stress hormone—called cortisol in humans)



TURN OFF ALL OTHER BODY SYSTEMS AND FOCUS ON THESE:

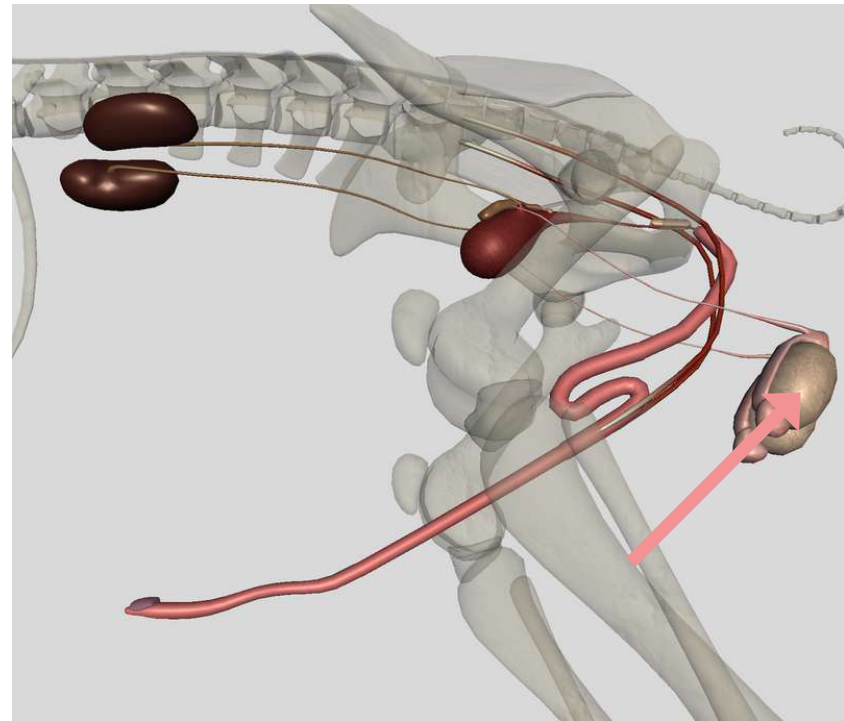
Skeleton

Urogenital

Testes

Location: at the rear end of male pigs, by the tail

Function: produce testosterone—male sex hormone—and produce sperm



TURN OFF ALL OTHER BODY SYSTEMS AND FOCUS ON THESE:

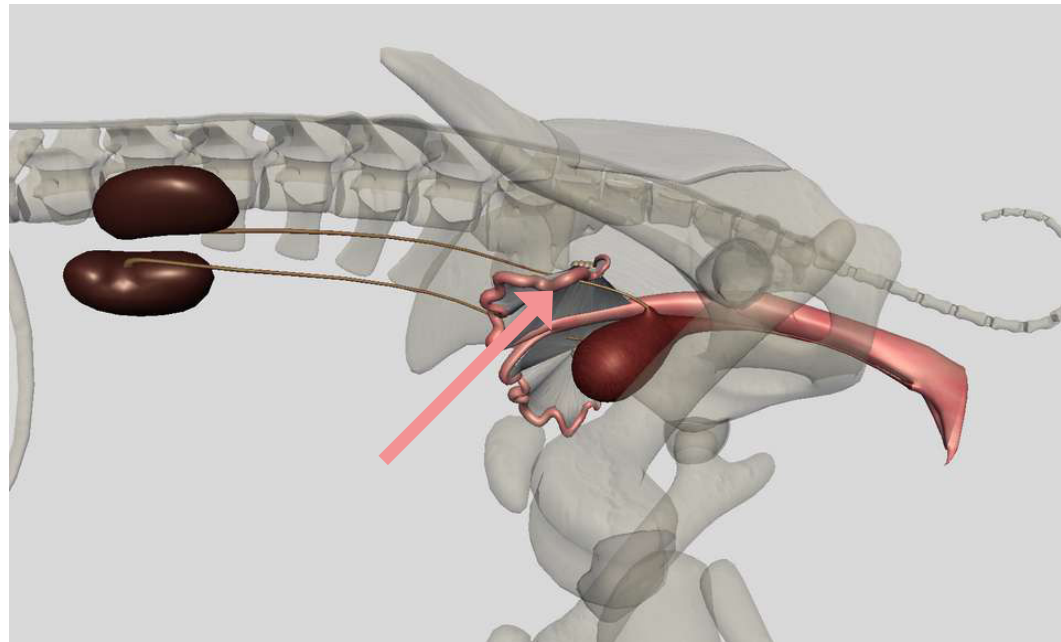
Skeleton

Urogenital

Ovaries

Location: in the internal pelvic region of female pigs

Function: produce estrogen and progesterone—female sex hormones—and produce eggs



TURN OFF ALL OTHER BODY SYSTEMS AND FOCUS ON THESE:

Skeleton

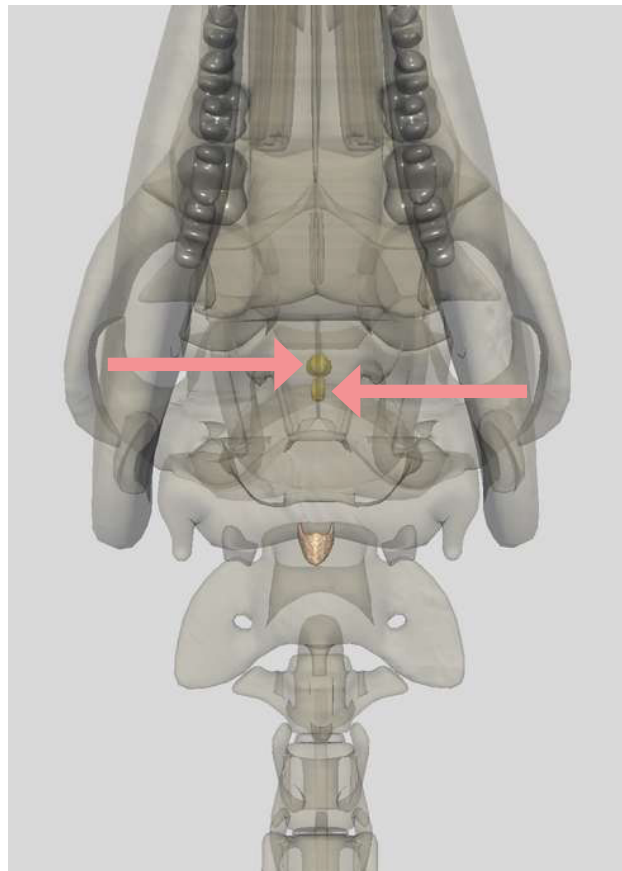
Endocrine

Pituitary and Hypothalamus

PITUITARY

Location: the underside of the pig brain

Function: 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.

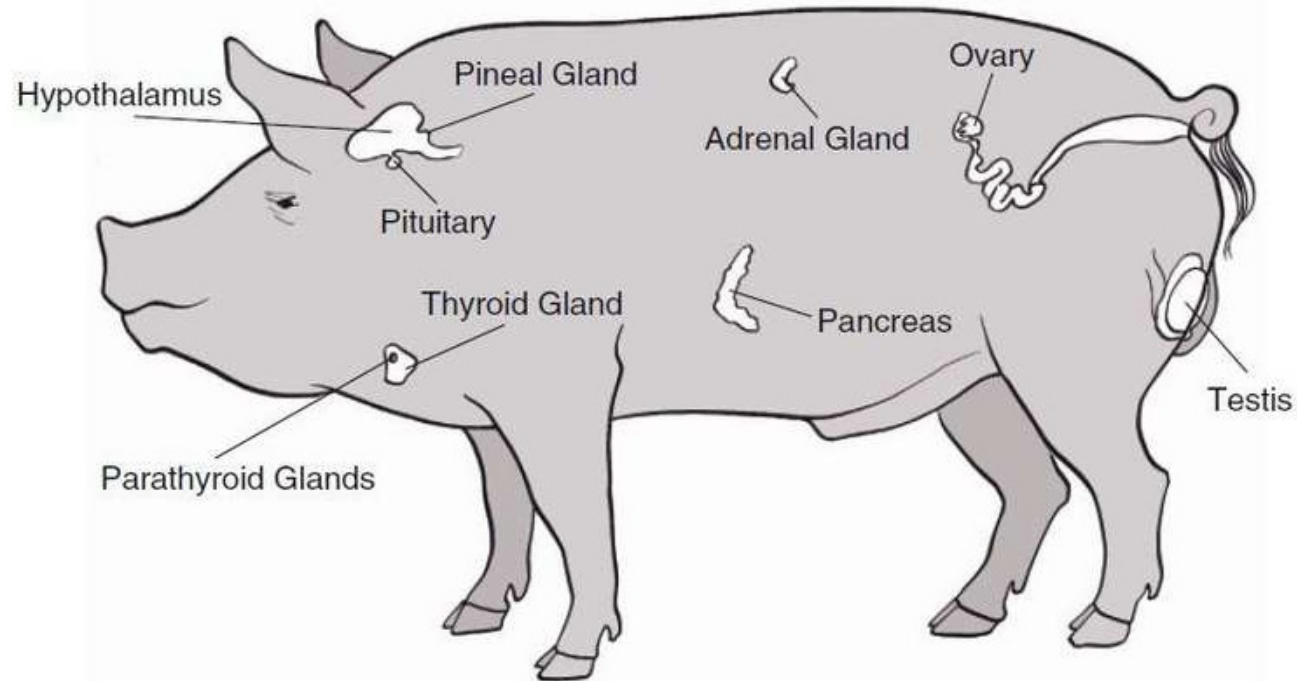


PINEAL GLAND

Location: deep in the center of the pig brain

Function: The main function of the pineal gland is to **receive information about the state of the light-dark** cycle from the environment and convey this information to produce and **secrete the hormone melatonin**.

Endocrine System Overview



REVIEW BREAK

With your group, draw an outline of a pig's body, and then add in the major endocrine glands. Choose one person to explain these to the class.

How Do Organ Systems Work Together?

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 pig'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.

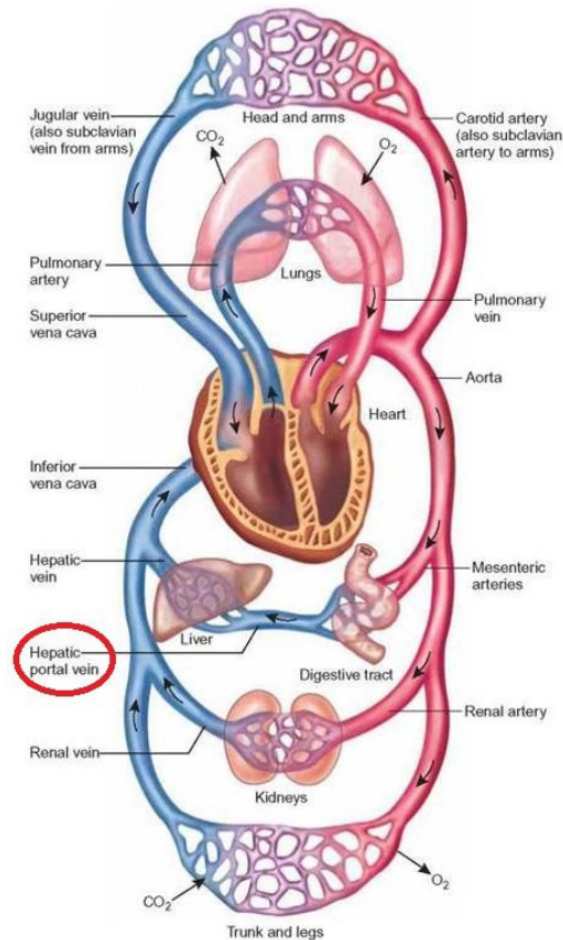
4. How do hormones interact with other body systems?

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



Identify Some Key Similarities and Differences Between Pigs and Humans

