Pig Anatomy Student Workbook

(accompanies 3D Pig Anatomy app by Biosphera)

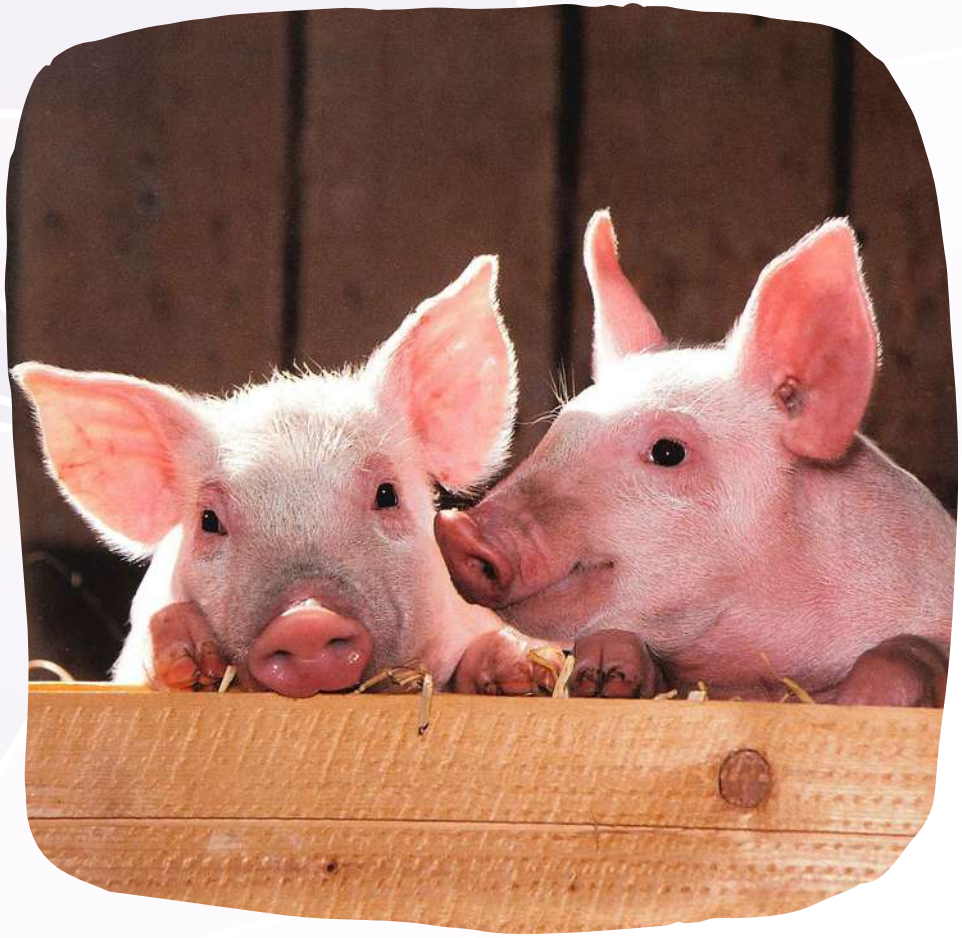
Contents

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!



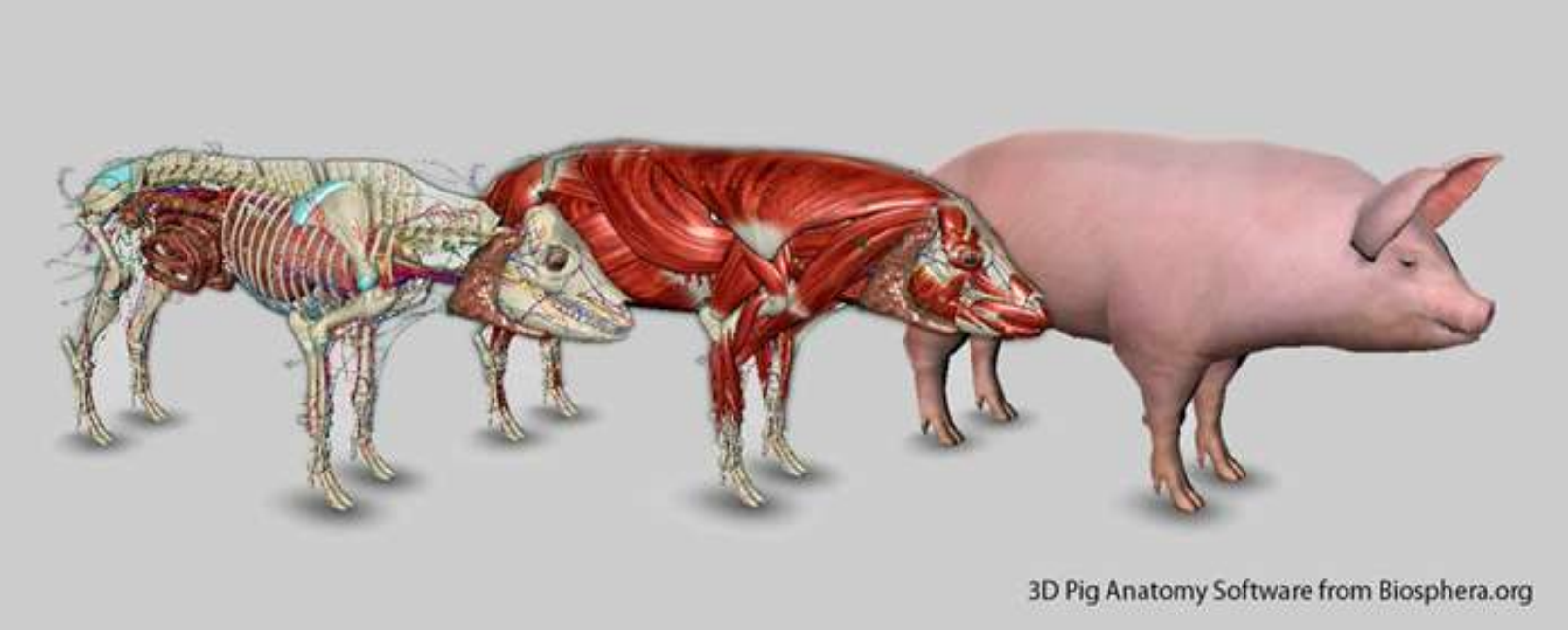
The body systems we will explore are:

Musculoskeletal
Respiratory
Circulatory
Digestive
Urinary
Nervous
Endocrine

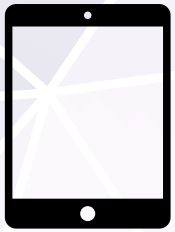
Getting To Know 3D Pig Anatomy

By: Biosphera

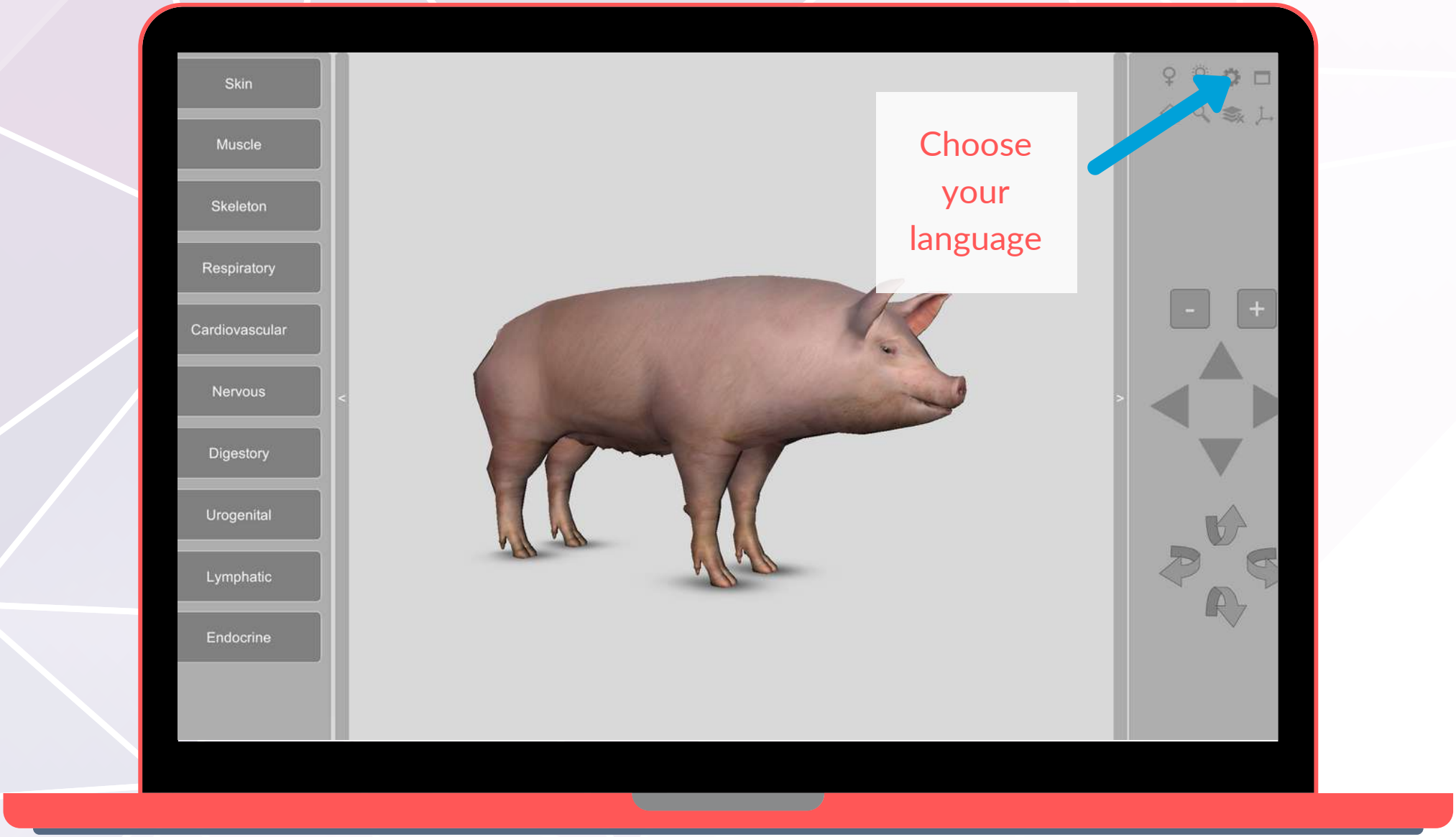
The app is available for iPads, Android tablets and desktop: www.biosphera.com

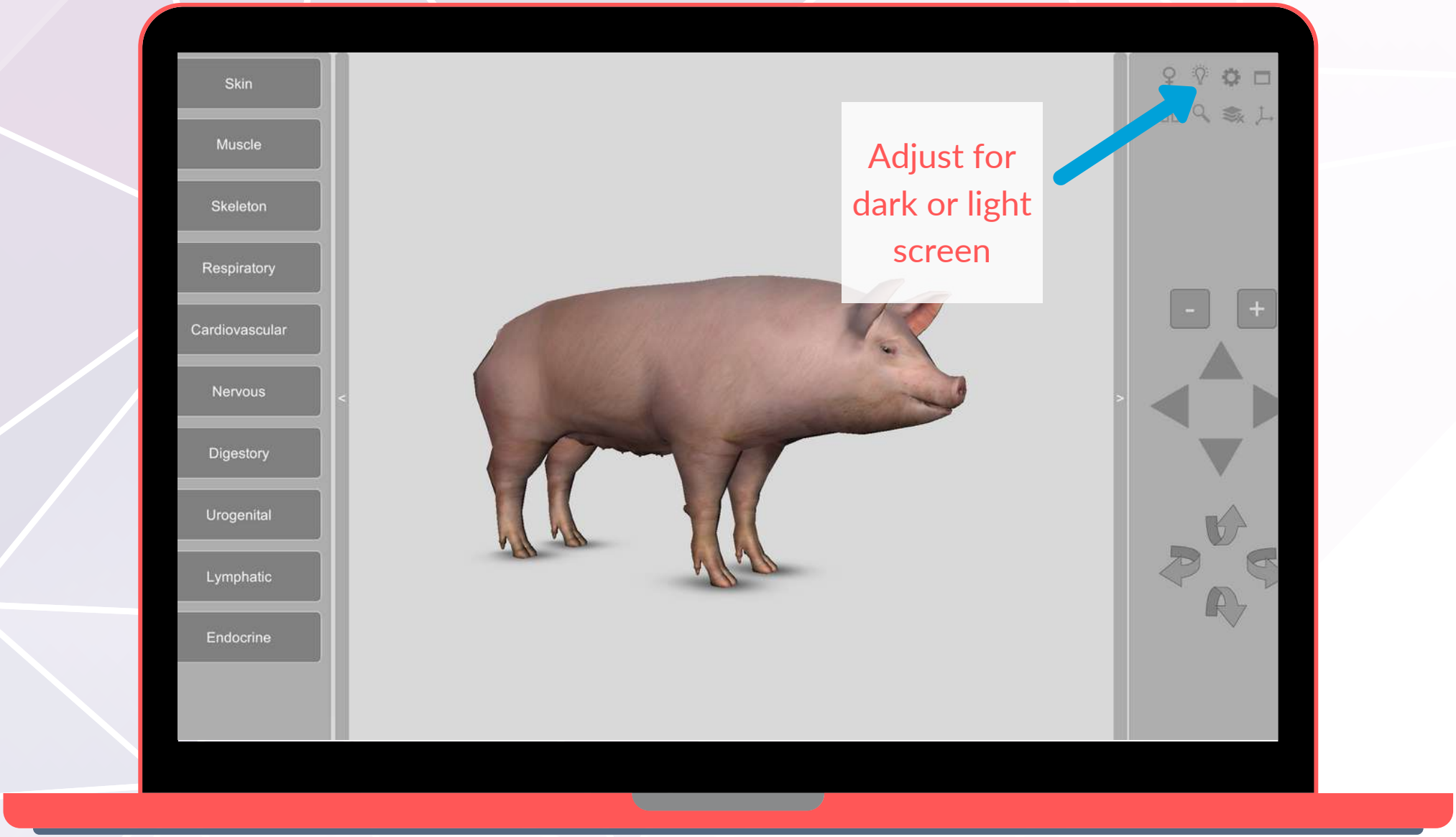


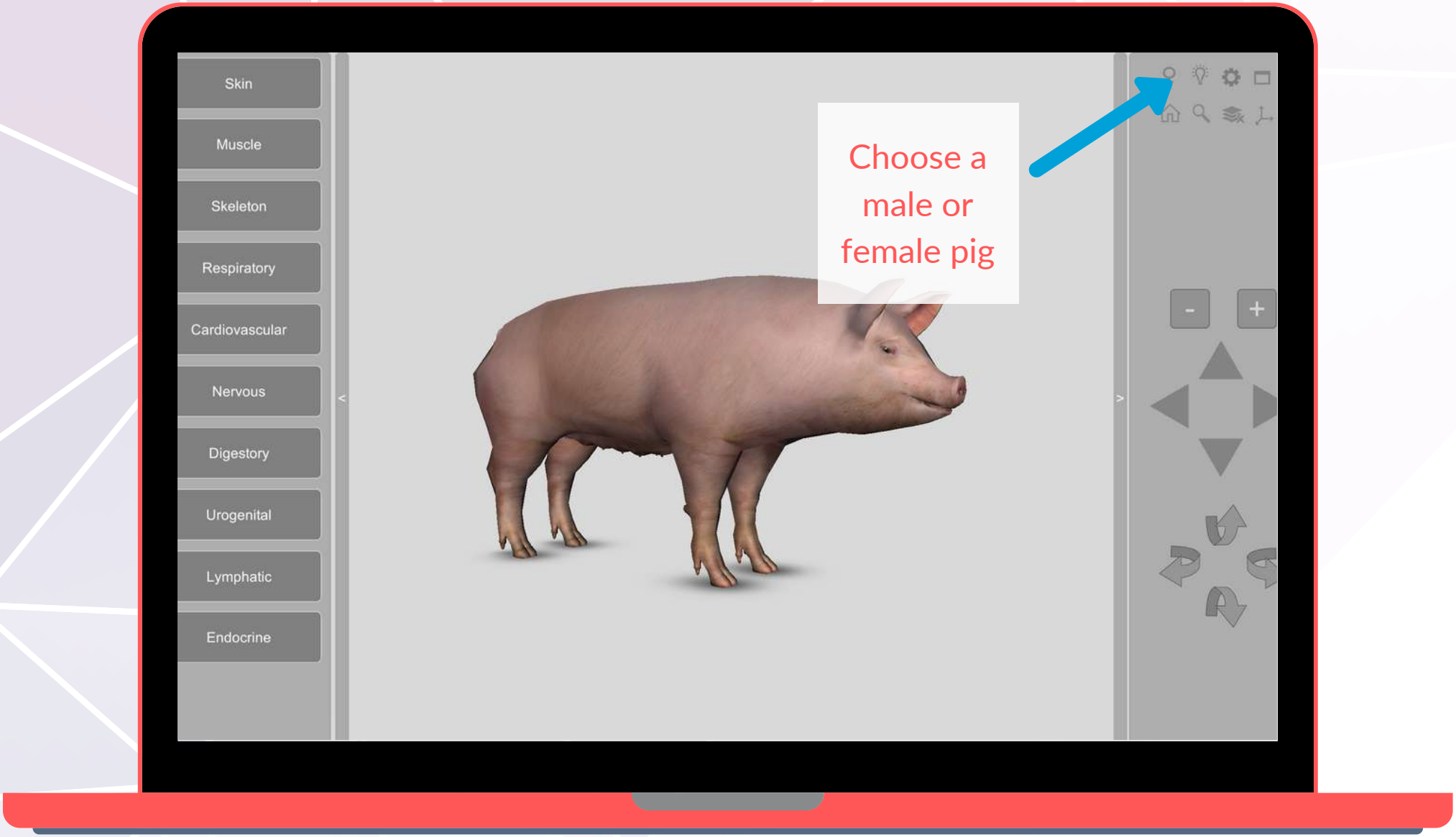
Let's Get Comfortable with the App!

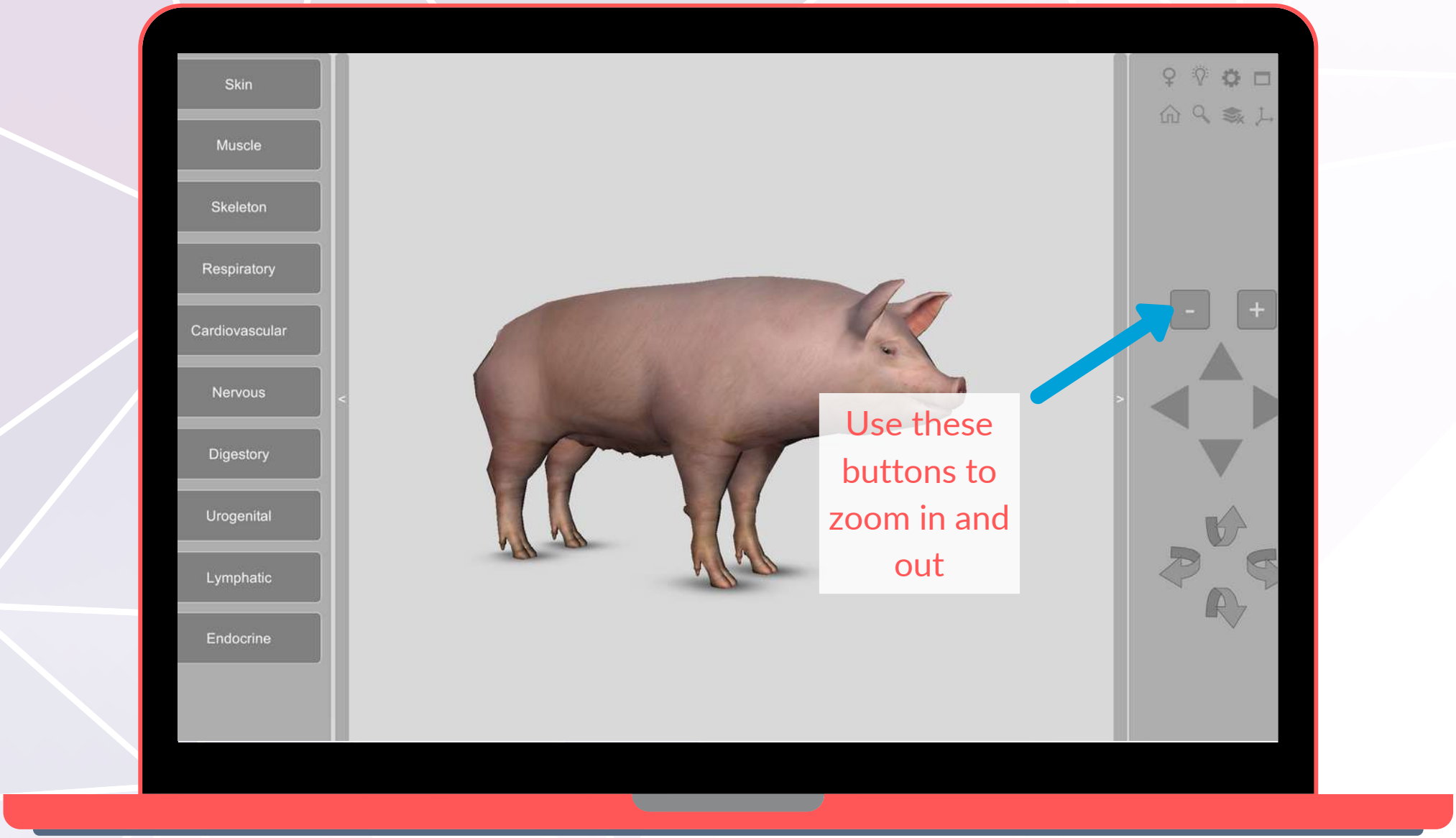


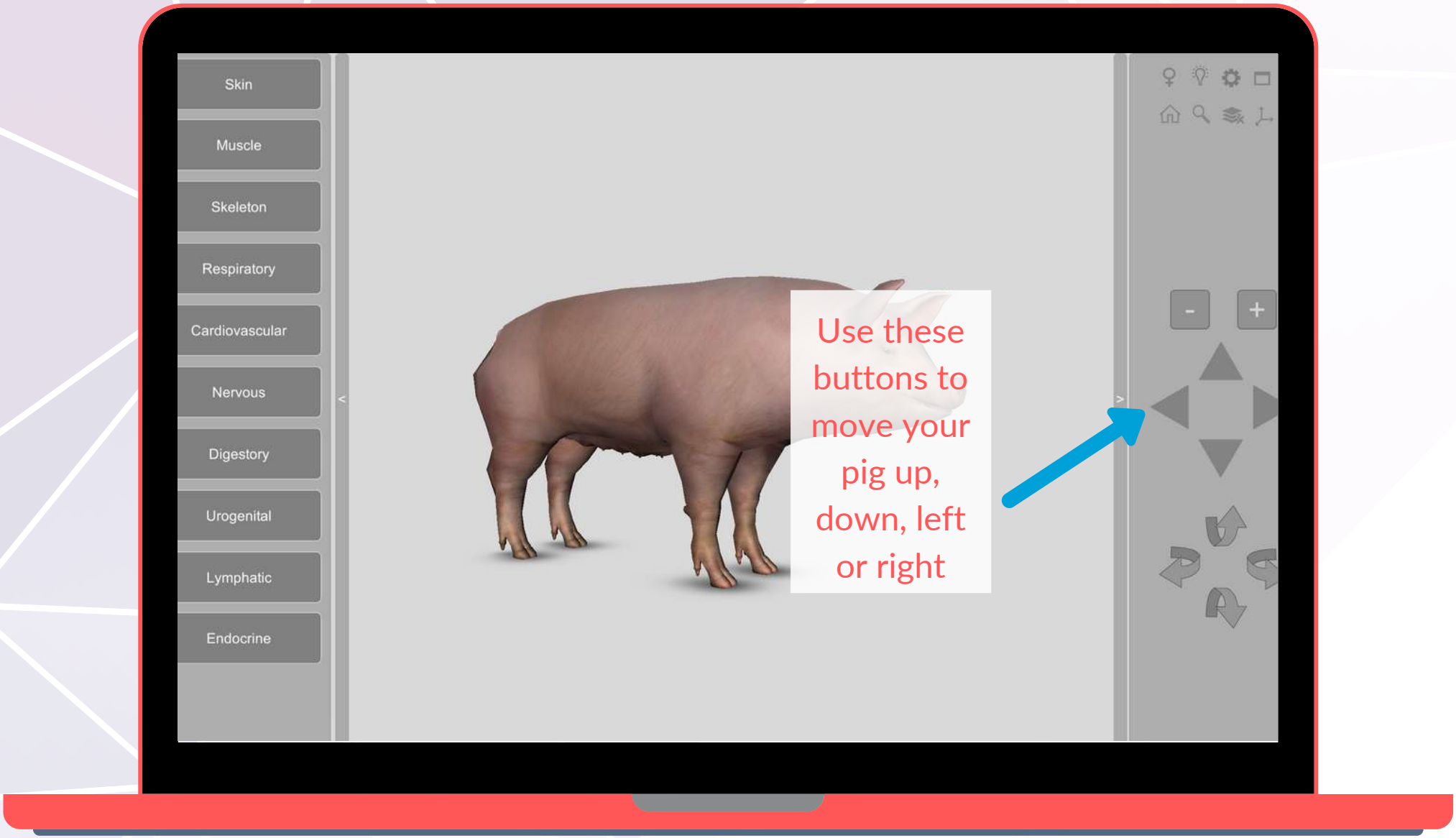
- Make sure everyone in your group takes a few minutes to explore the app
- Press buttons, move the model around, and touch/hold the organs… See what happens!

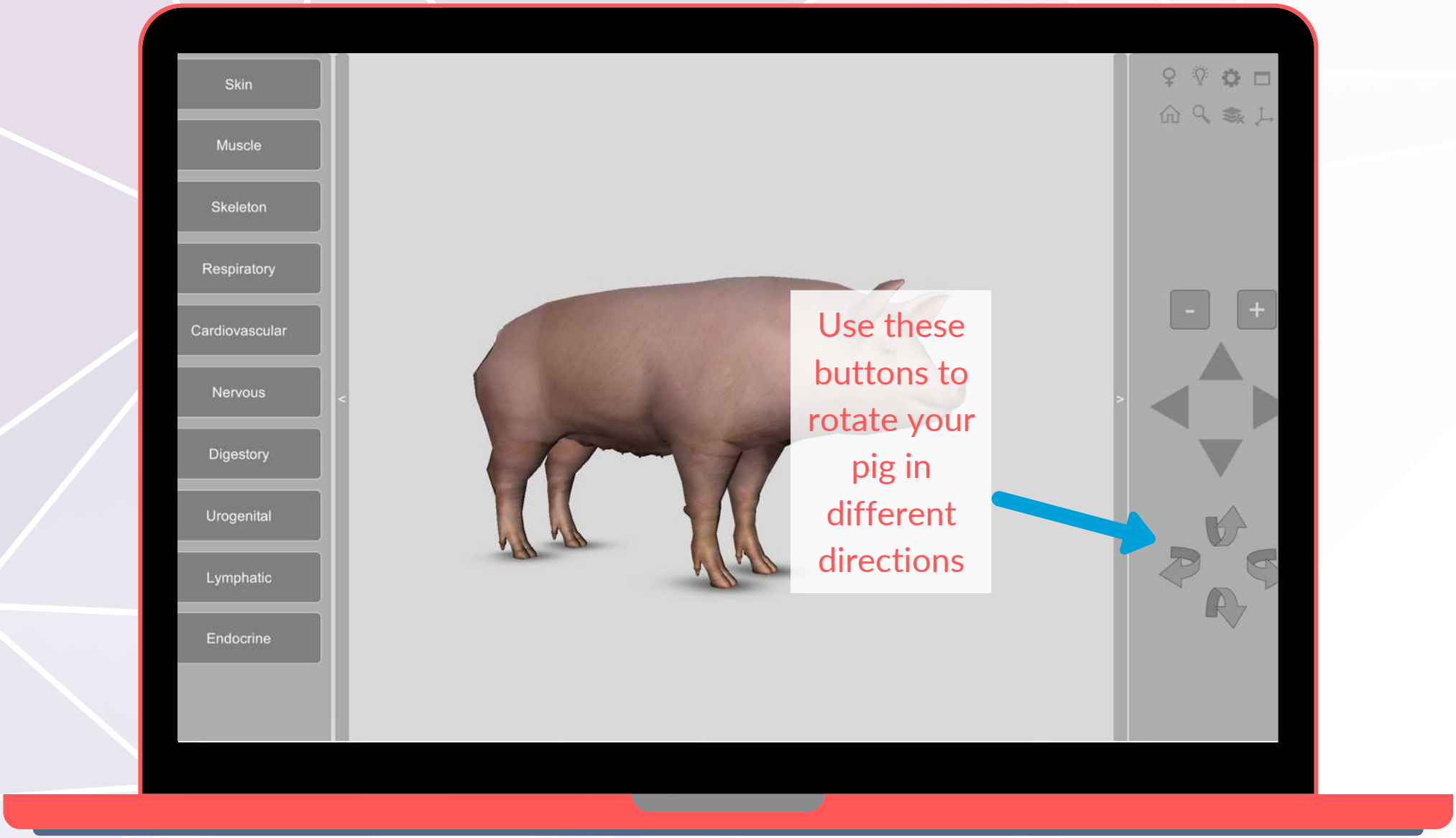


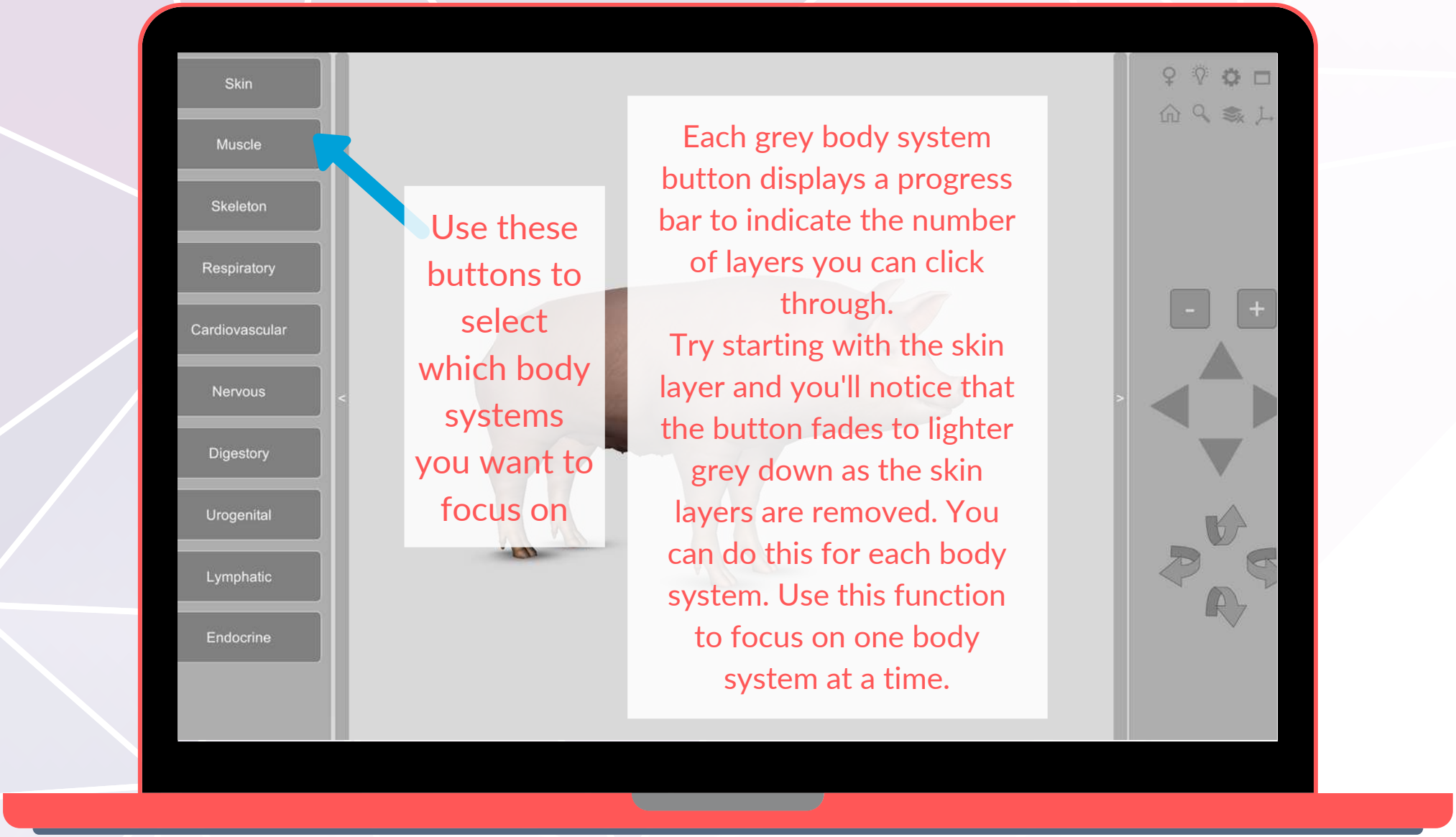




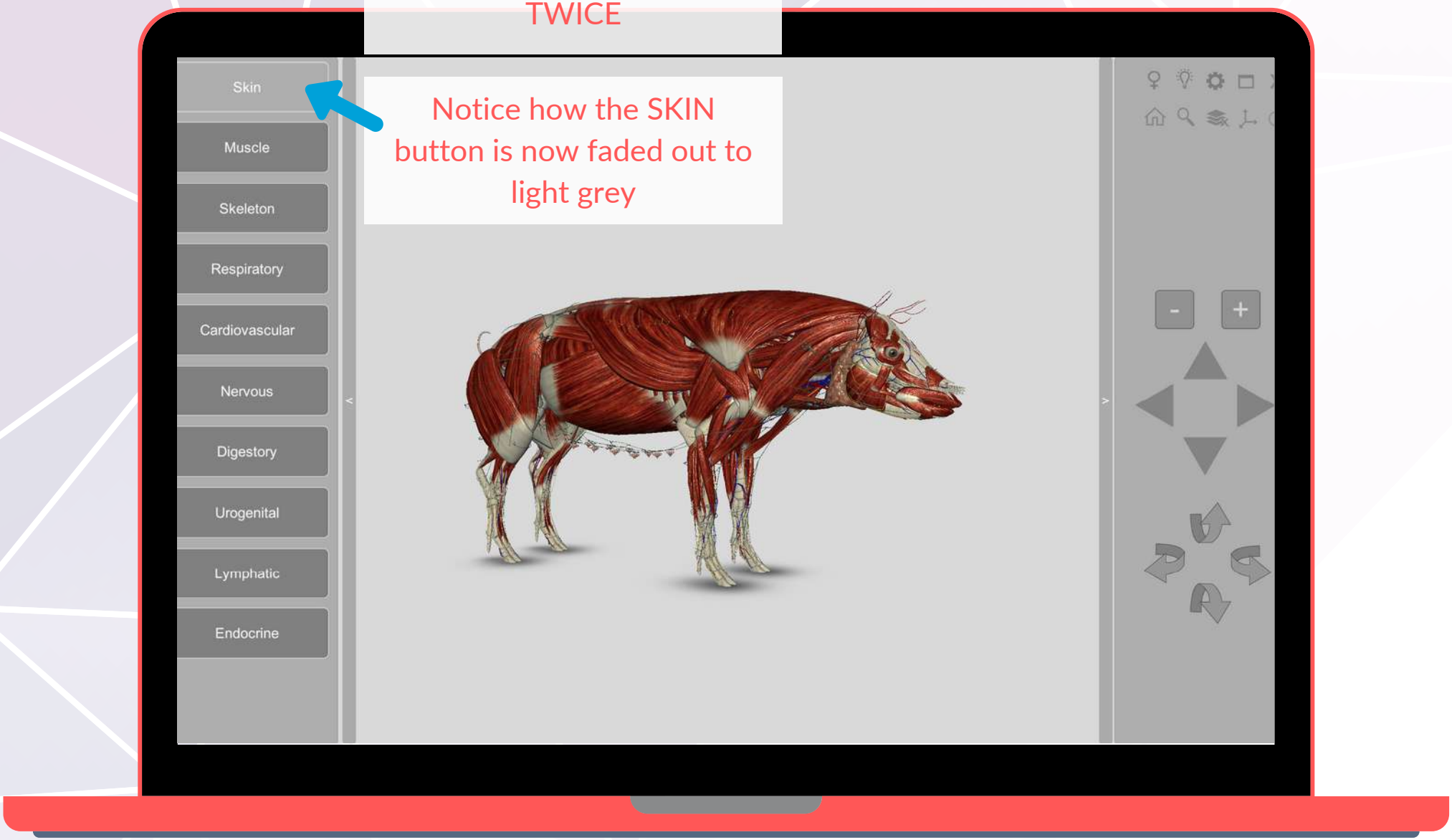








Here's what your pig should look like when you click the SKIN button TWICE

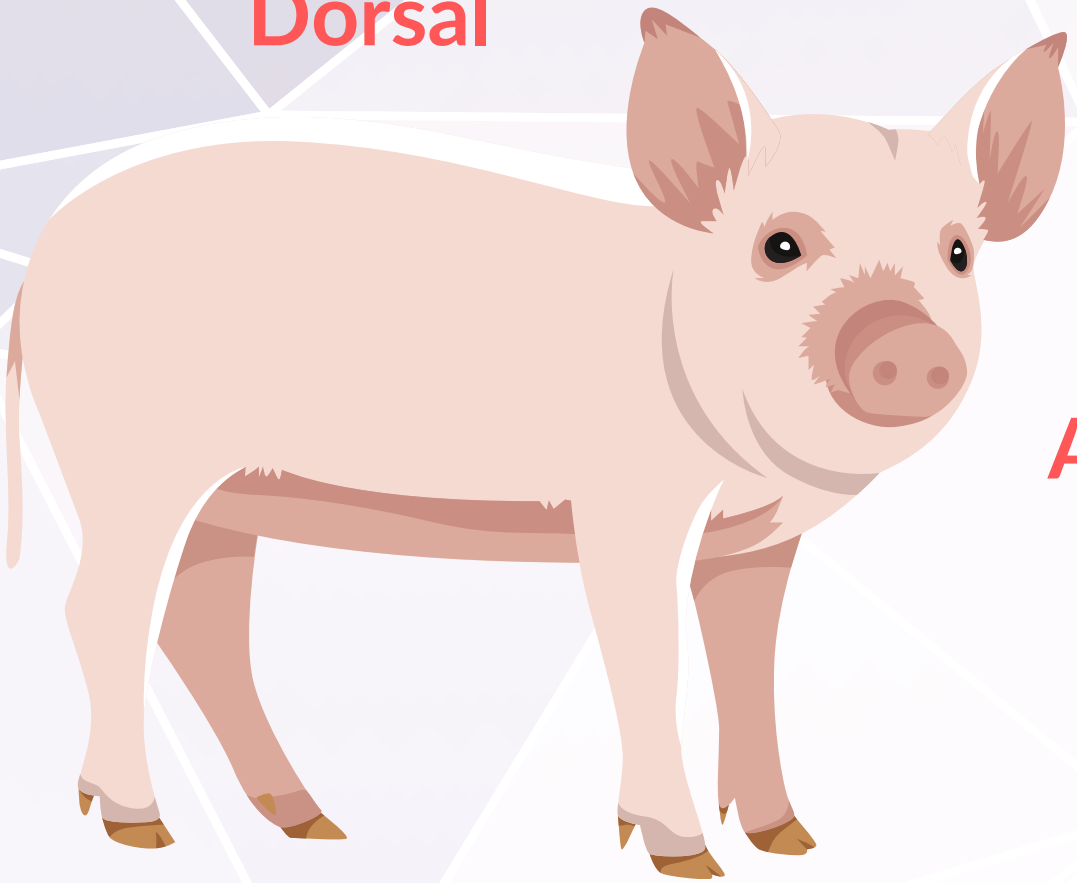


Notice how the SKIN button is now faded out to light grey

Some Terms To Know

Dorsal

Posterior



Anterior

Ventral

One More Thing!

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

make sure your app has the same buttons, and layers showing.

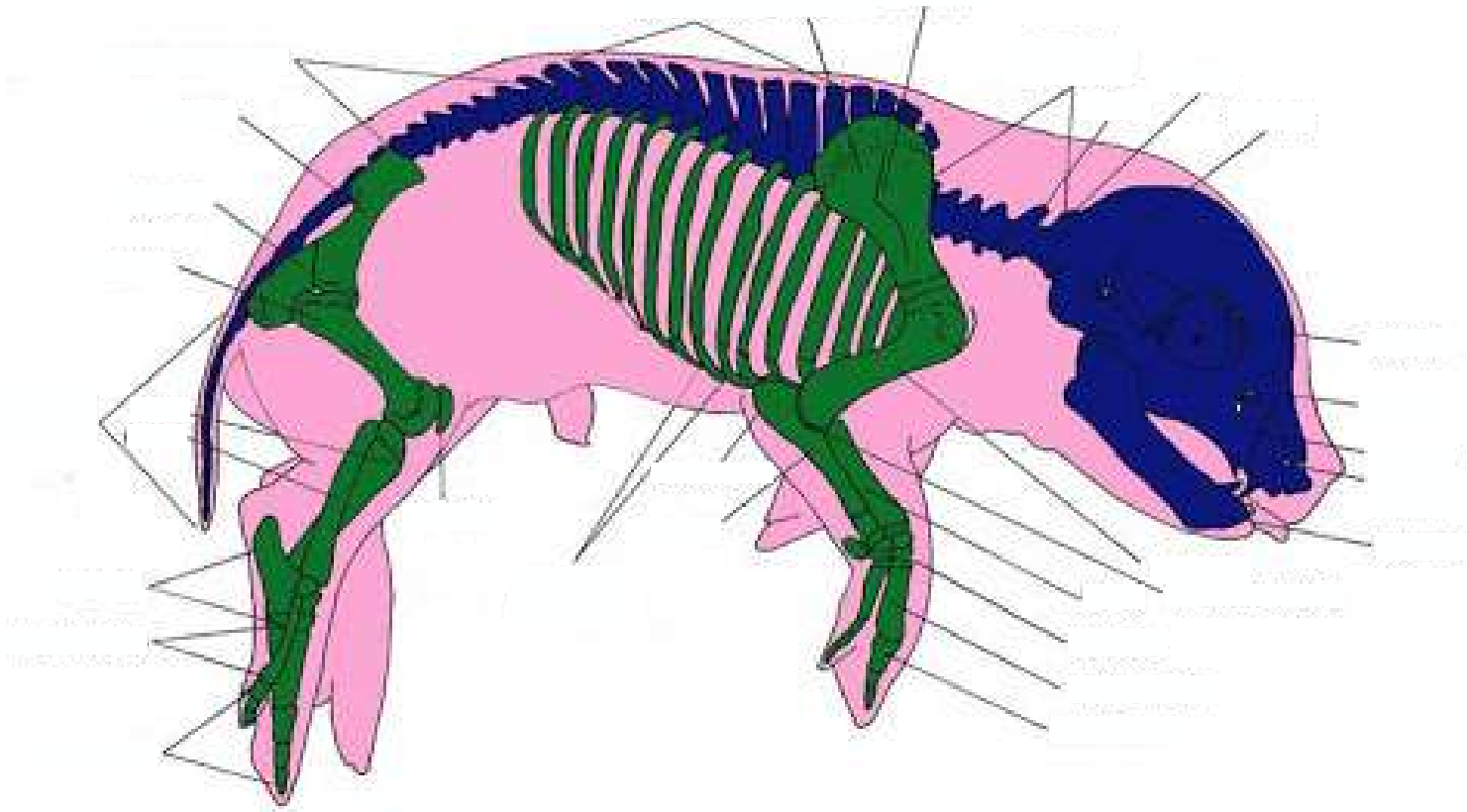
Musculoskeletal system

Bones

Turn off all other body systems and focus on the skeleton

Skeleton

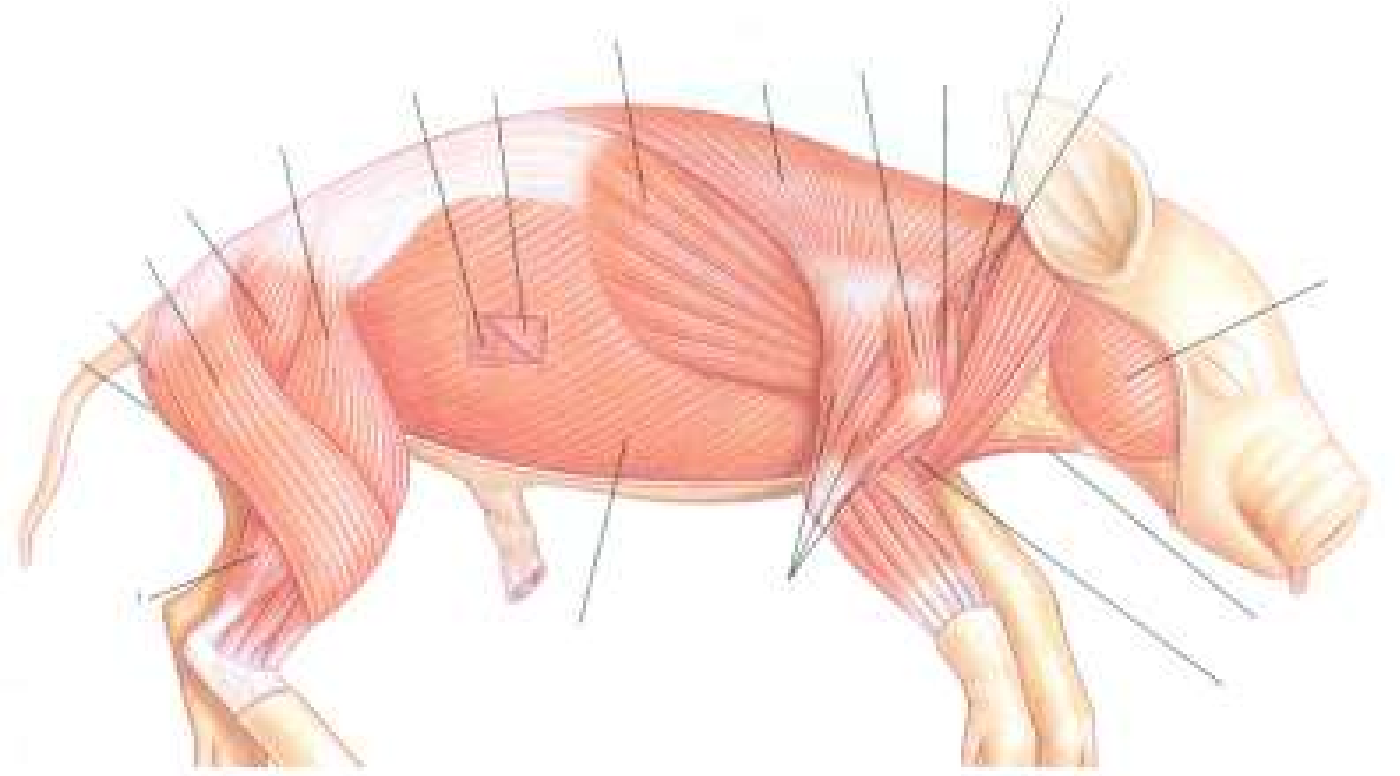
Use your 3D Pig Anatomy app to label all the bones on this fetal pig skeleton



Muscles

Turn off all other body systems and focus on the skeleton → **Muscles**

Use your 3D Pig Anatomy app to label all the muscles on this diagram



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

Lungs and Trachea

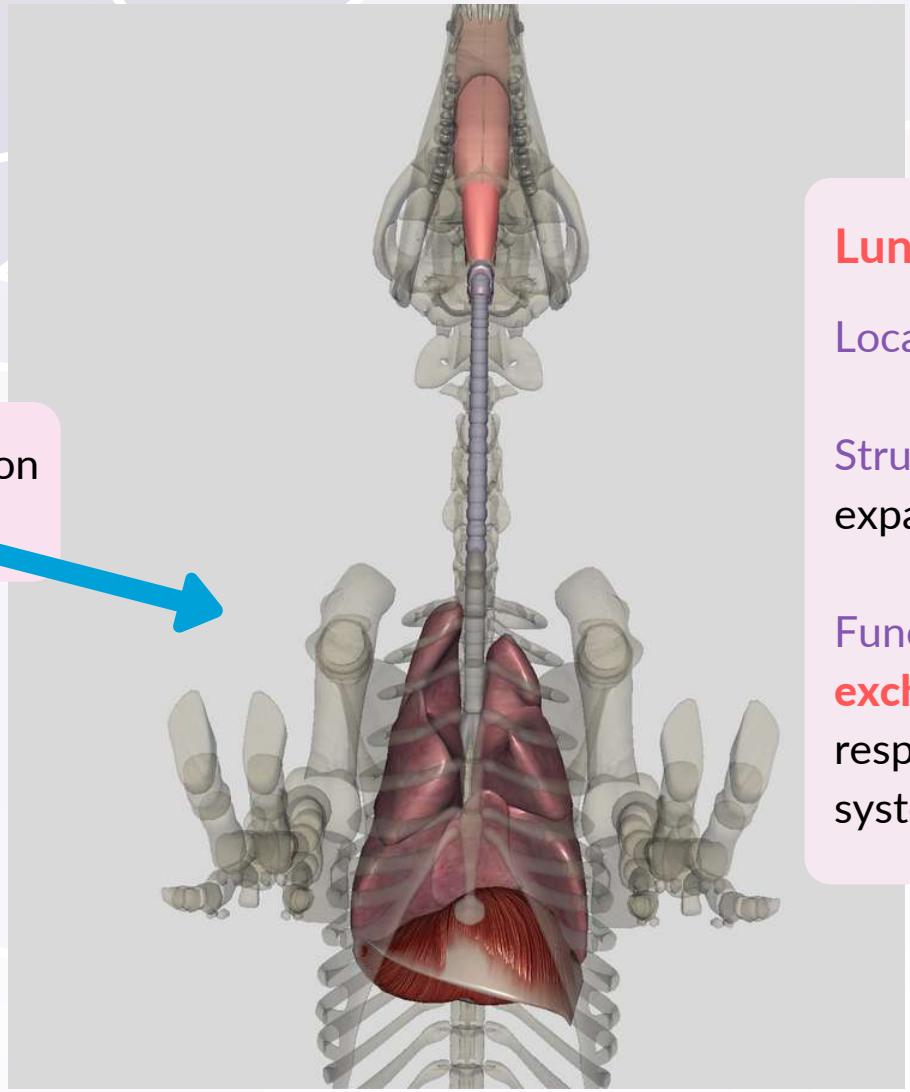
Turn off all other body systems and focus on these

- Skeleton
- Respiratory

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

Location: chest cavity

Structure: large, spongy expandable organ

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

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

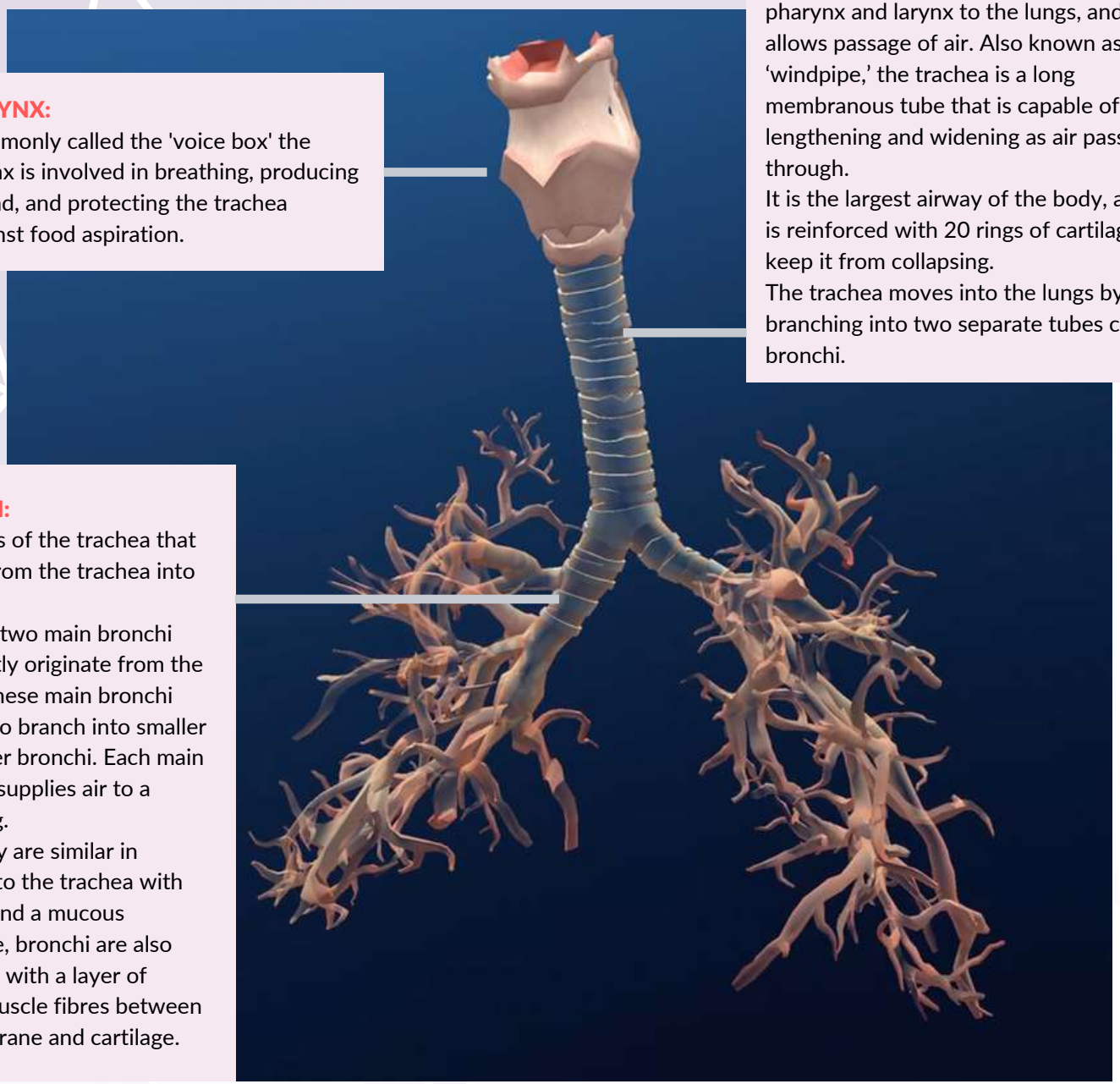
- The **heart** is located on the **left side**
- Most animals have fewer lung lobes (including humans) on the left side of the body to **make room for the heart**

Why would the **trachea** be linked with **cartilage rings?**

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

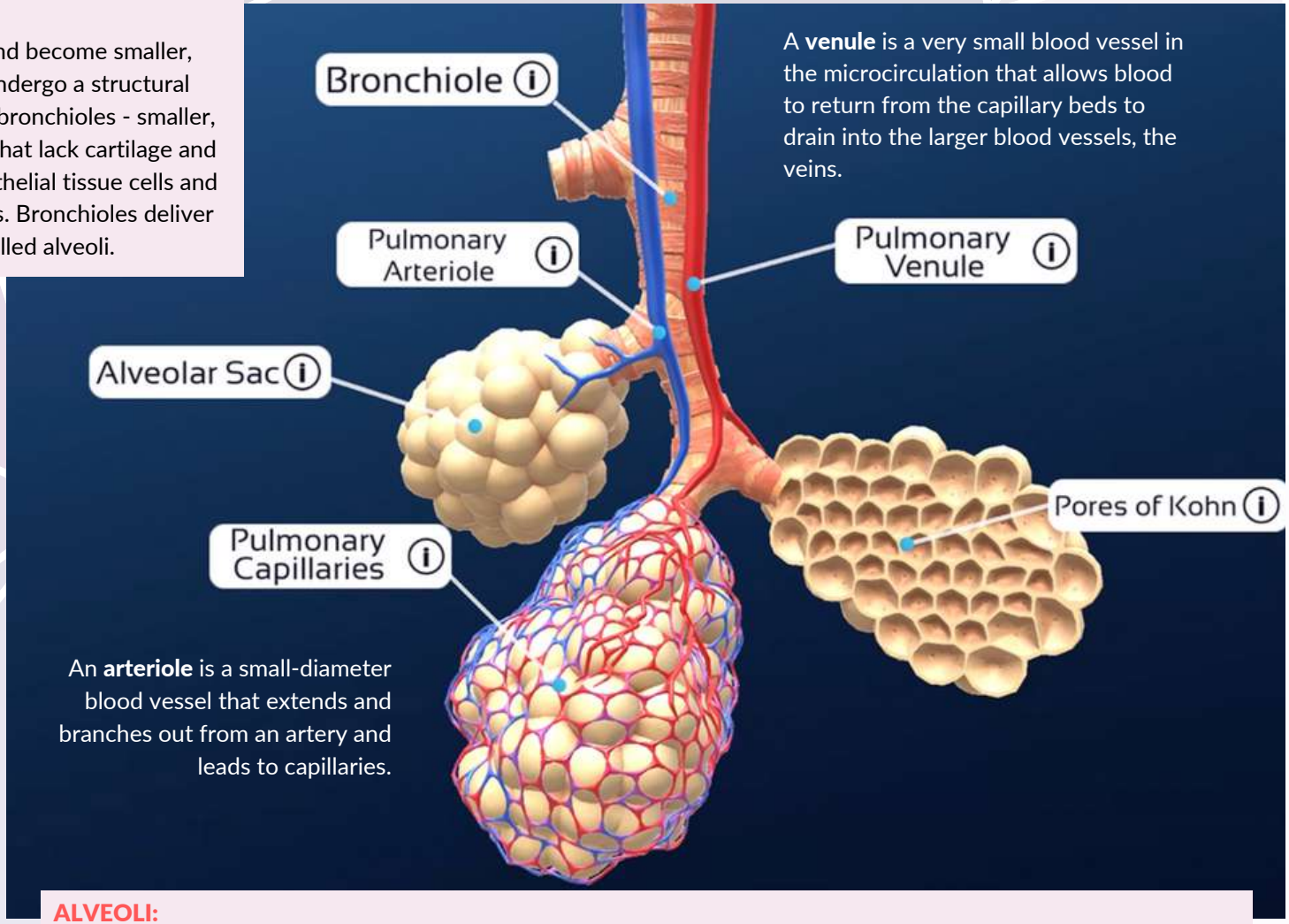
LARYNX:
Commonly called the 'voice box' the larynx is involved in breathing, producing sound, and protecting the trachea against food aspiration.

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.



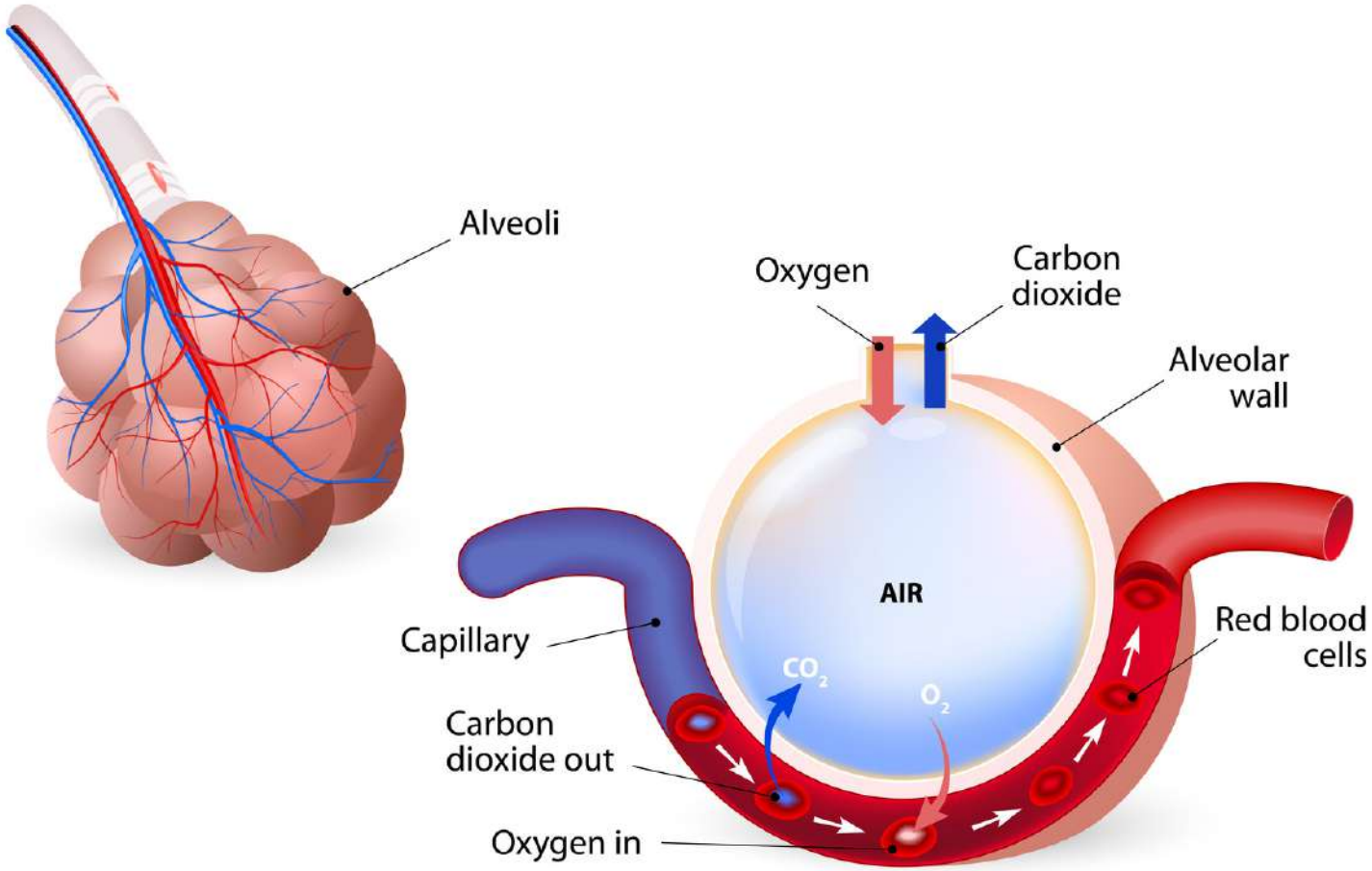
BRONCHI:
Extensions of the trachea that carry air from the trachea into the lungs.
There are two main bronchi that directly originate from the trachea; these main bronchi continue to branch into smaller and smaller bronchi. Each main bronchus supplies air to a single lung.
While they are similar in structure 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.

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

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

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

Bronchial tube

- Within the lungs, it branches further into **bronchioles**

Bronchioles

- Tiny, **thin** walled sacs are on the end of the bronchioles called **alveoli**

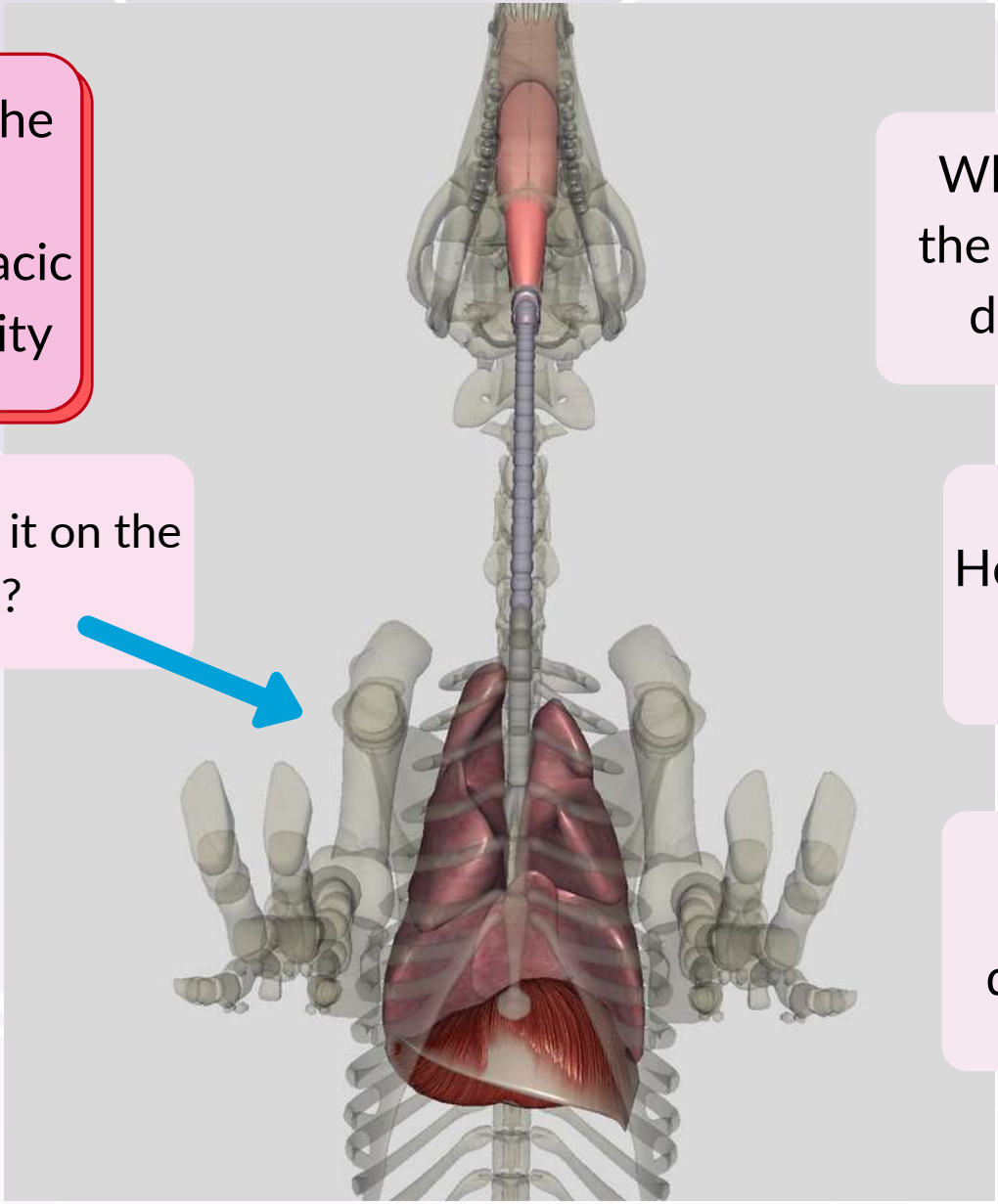
Alveoli

- Site of **oxygen exchange**

The Diaphragm

The **diaphragm** is the layer of muscle separating the thoracic and abdominal cavity

Can you label it on the image?

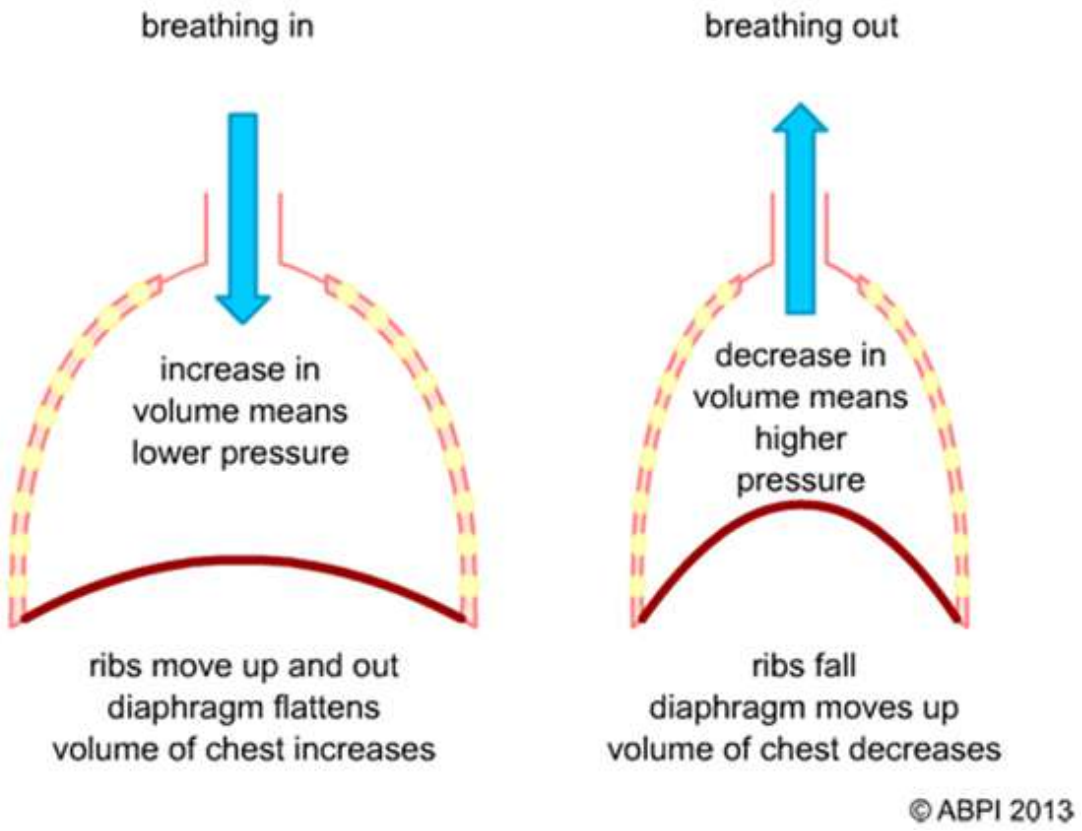


What would happen to the thoracic cavity if the diaphragm flattens?

How does this assist in breathing?

What happens during an exhale?

Most mammals breath using negative pressure breathing



FUN FACT!

Frogs don't have a diaphragm so they create a negative pressure gradients using their mouth and throat sack.

- **Gasses move from high pressure areas to low pressure areas**
- **How is this different in animals like frogs?**

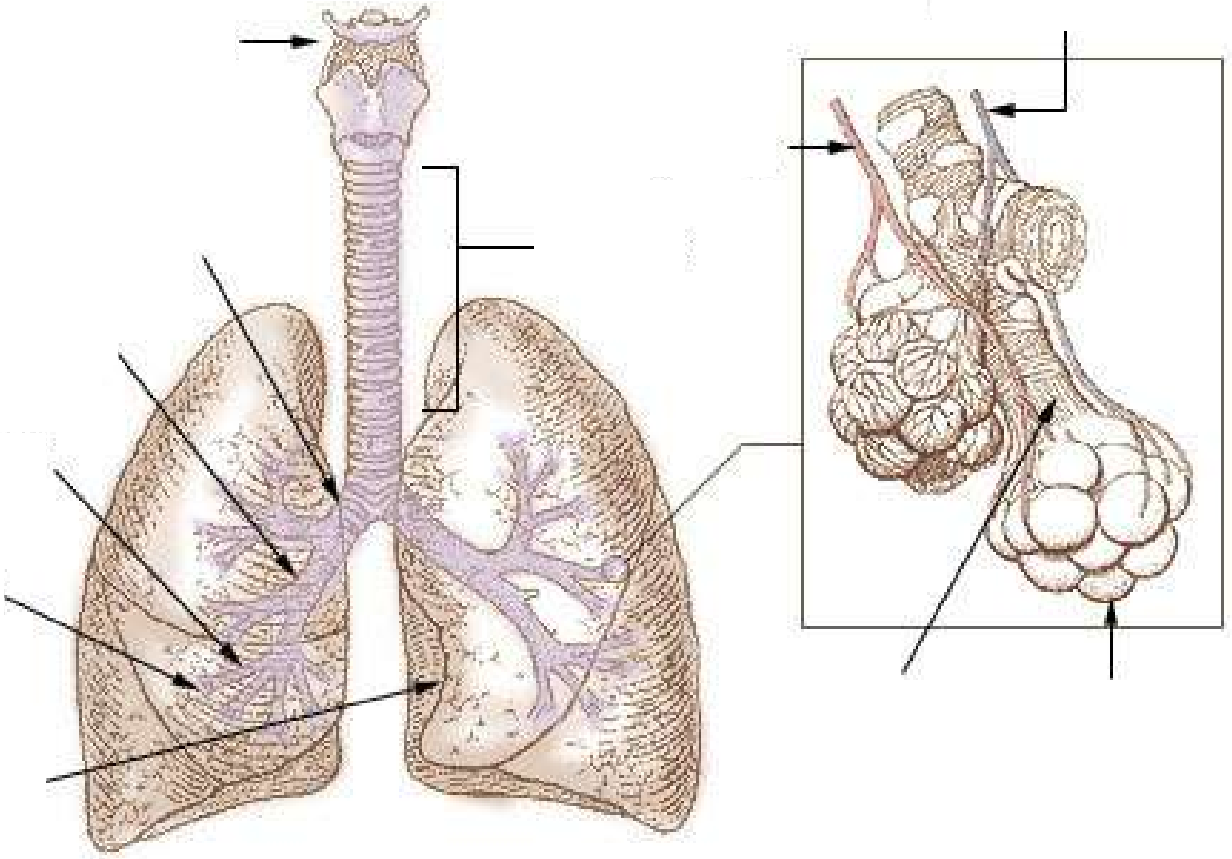
Review Break

- 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

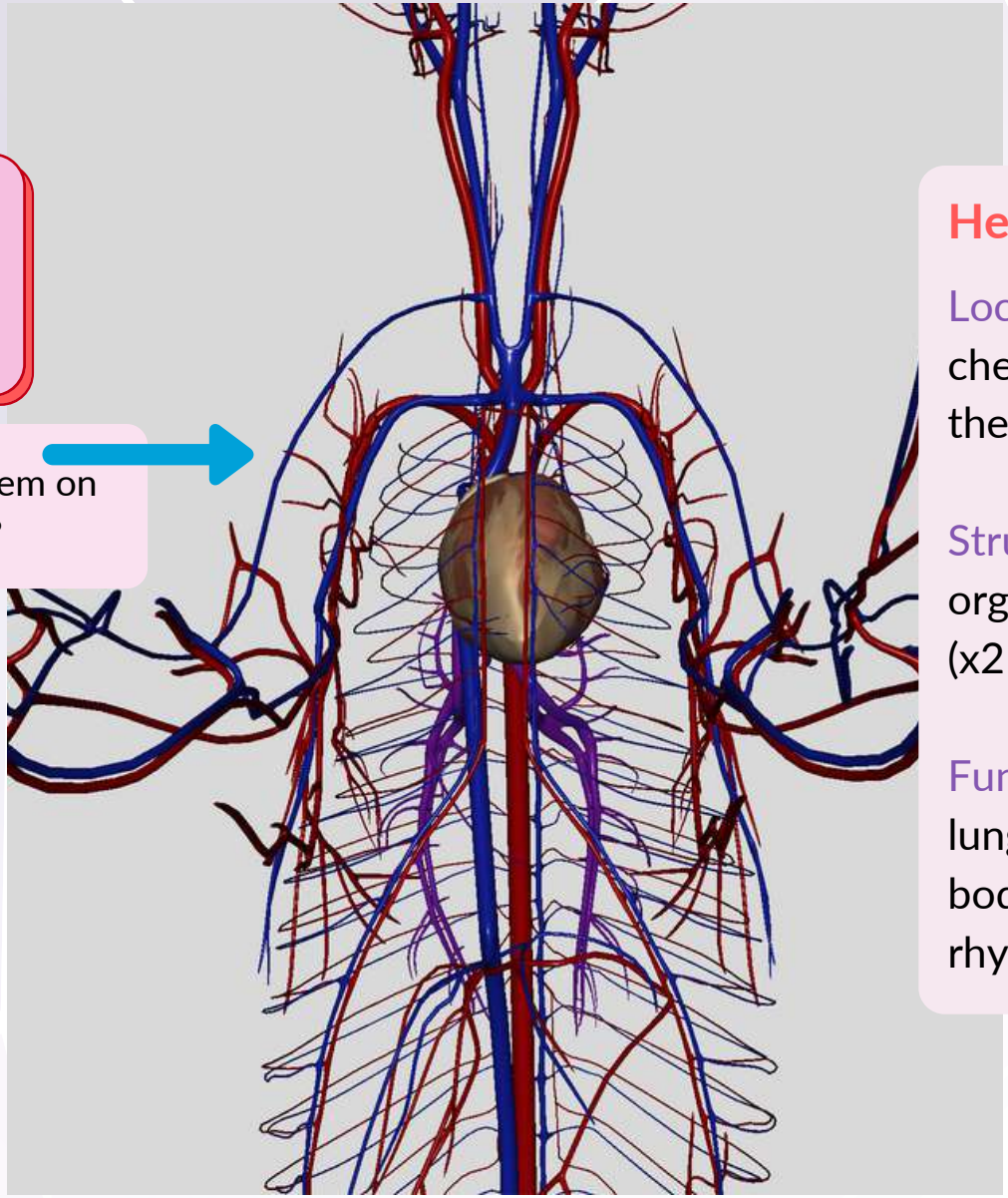
Skeleton

Circulatory

Locate the pig's **heart**

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

Can you label them on the image?



Heart

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

Structure: strong muscular organ with four chambers (x2 atria, x2 ventricles)

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

Do arteries **always** carry oxygenated blood and the veins deoxygenated blood?

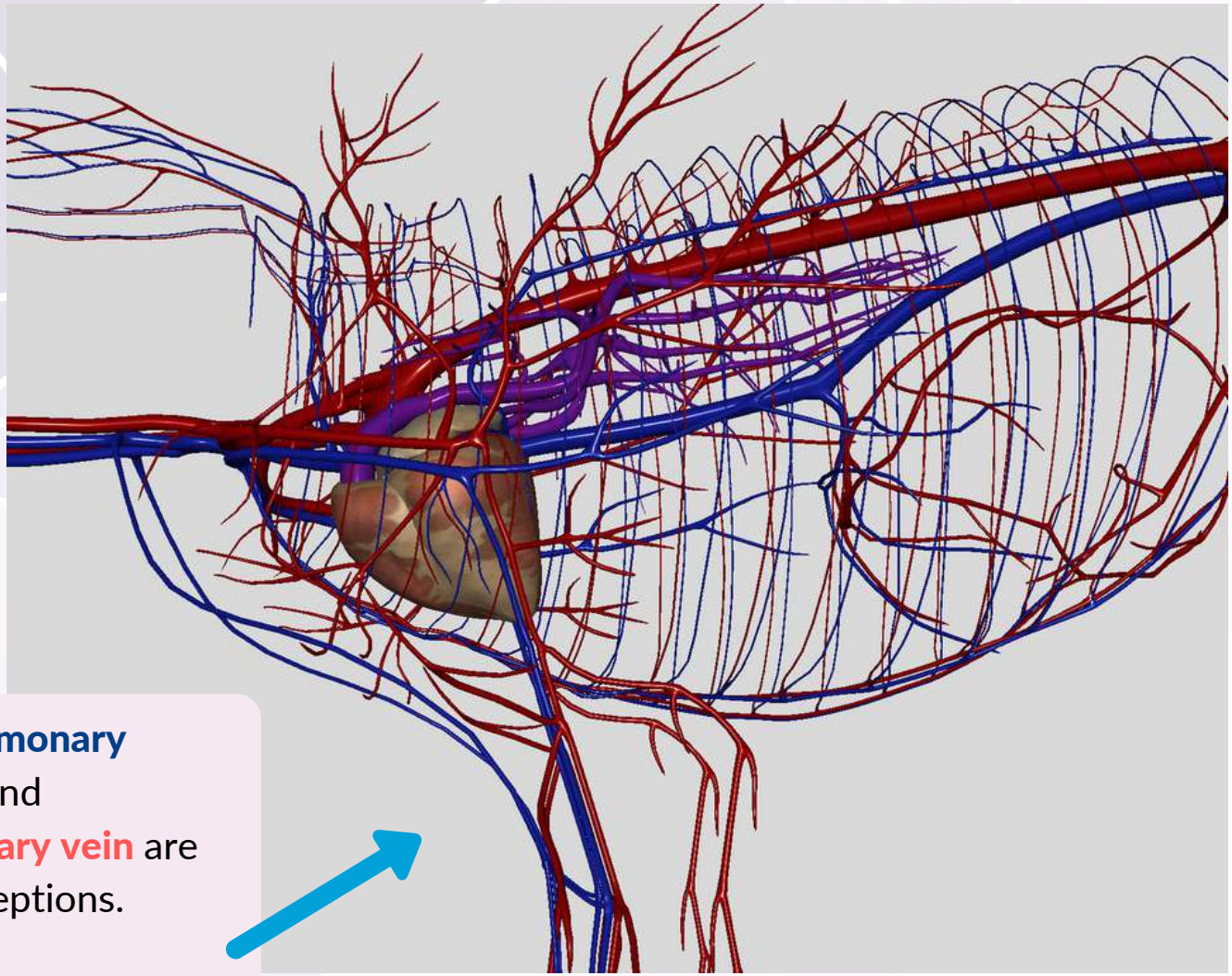
No, there are TWO exceptions, but **arteries always** carry blood away from the heart, and **veins always** carry blood towards the heart

The **pulmonary artery** and **pulmonary vein** are the exceptions.

Can you locate them and label them on the image?

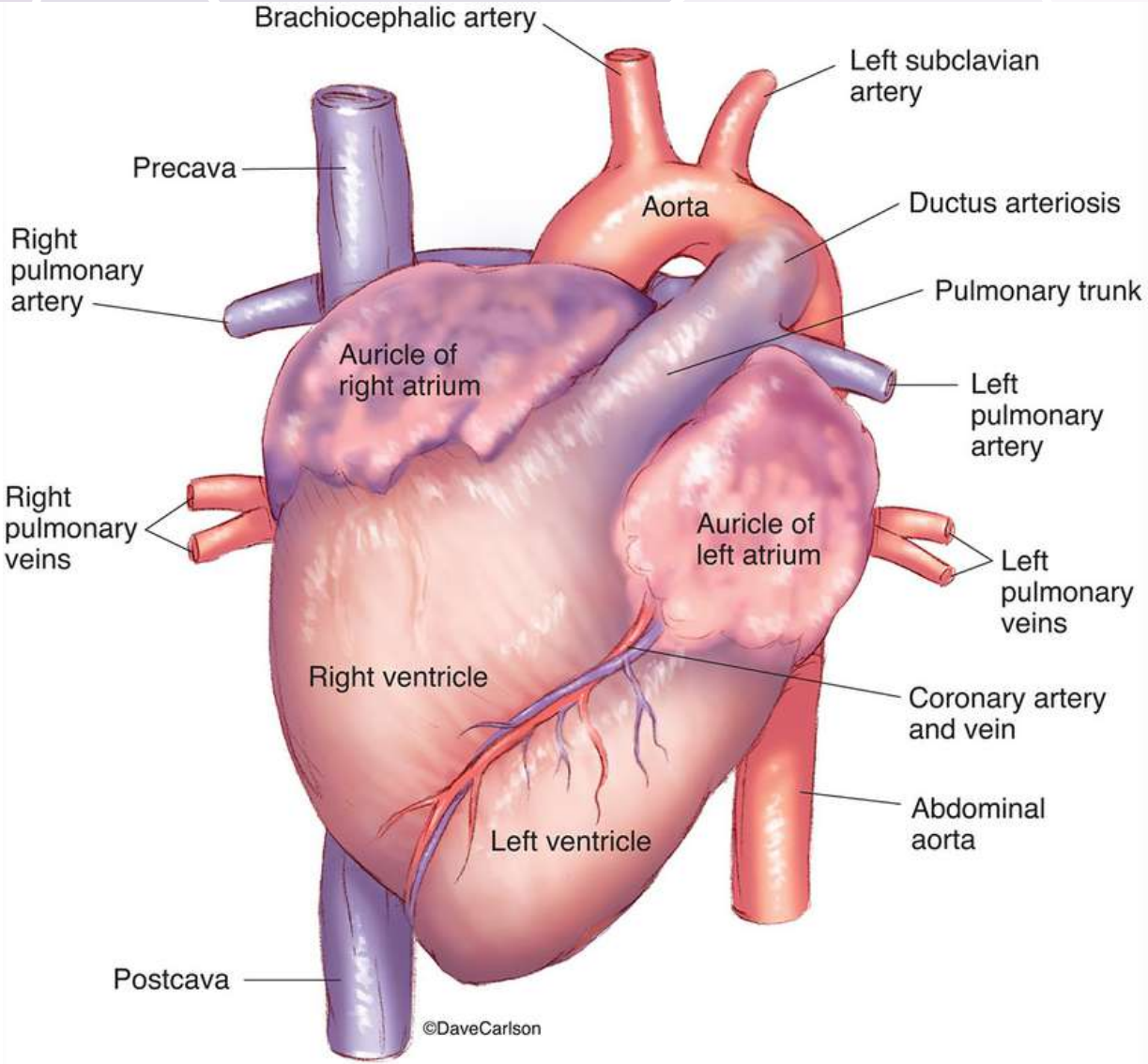
Pig's head ←

→ Pig's tail



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

The Heart

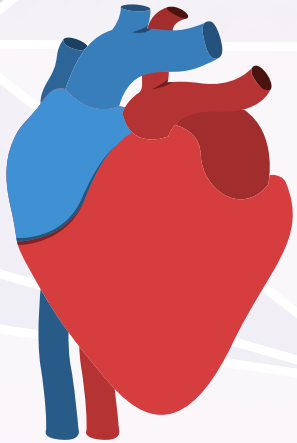


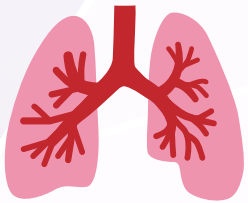
Blood Flow Through The Heart

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 **right ventricle** via the **tricuspid valve**

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





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

Blood is then pumped from the left atrium to the **left ventricle** via the **bicuspid (mitral) valve**

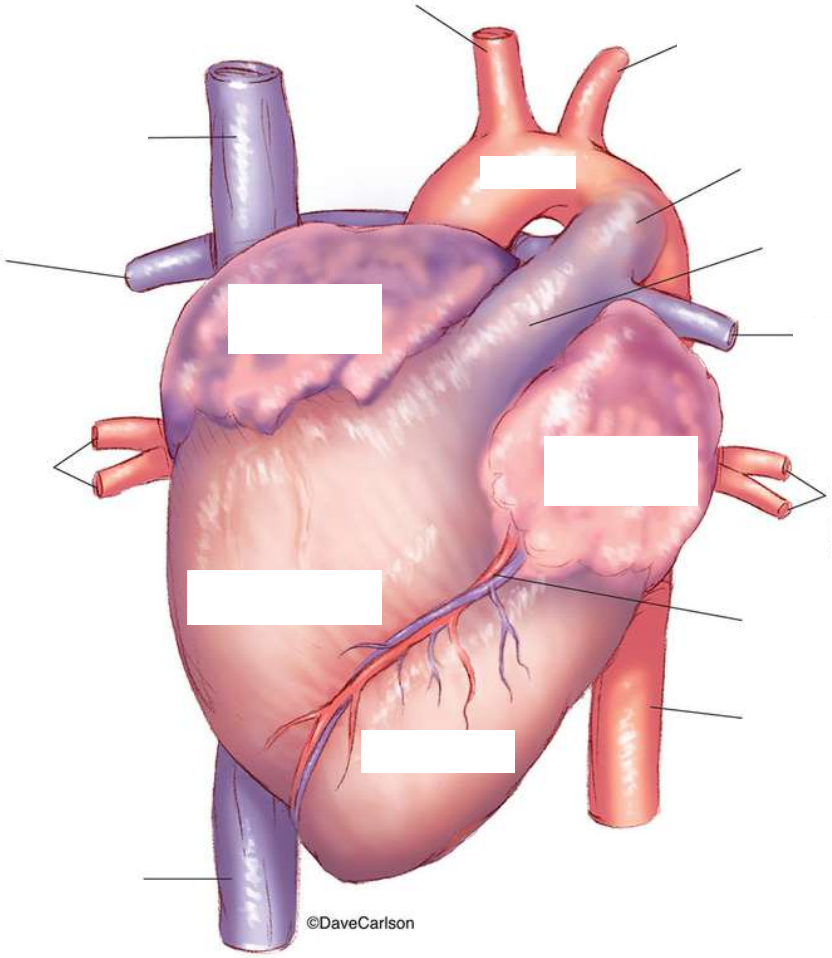
The left ventricle pumps **oxygenated** blood out to the body via the **aorta**

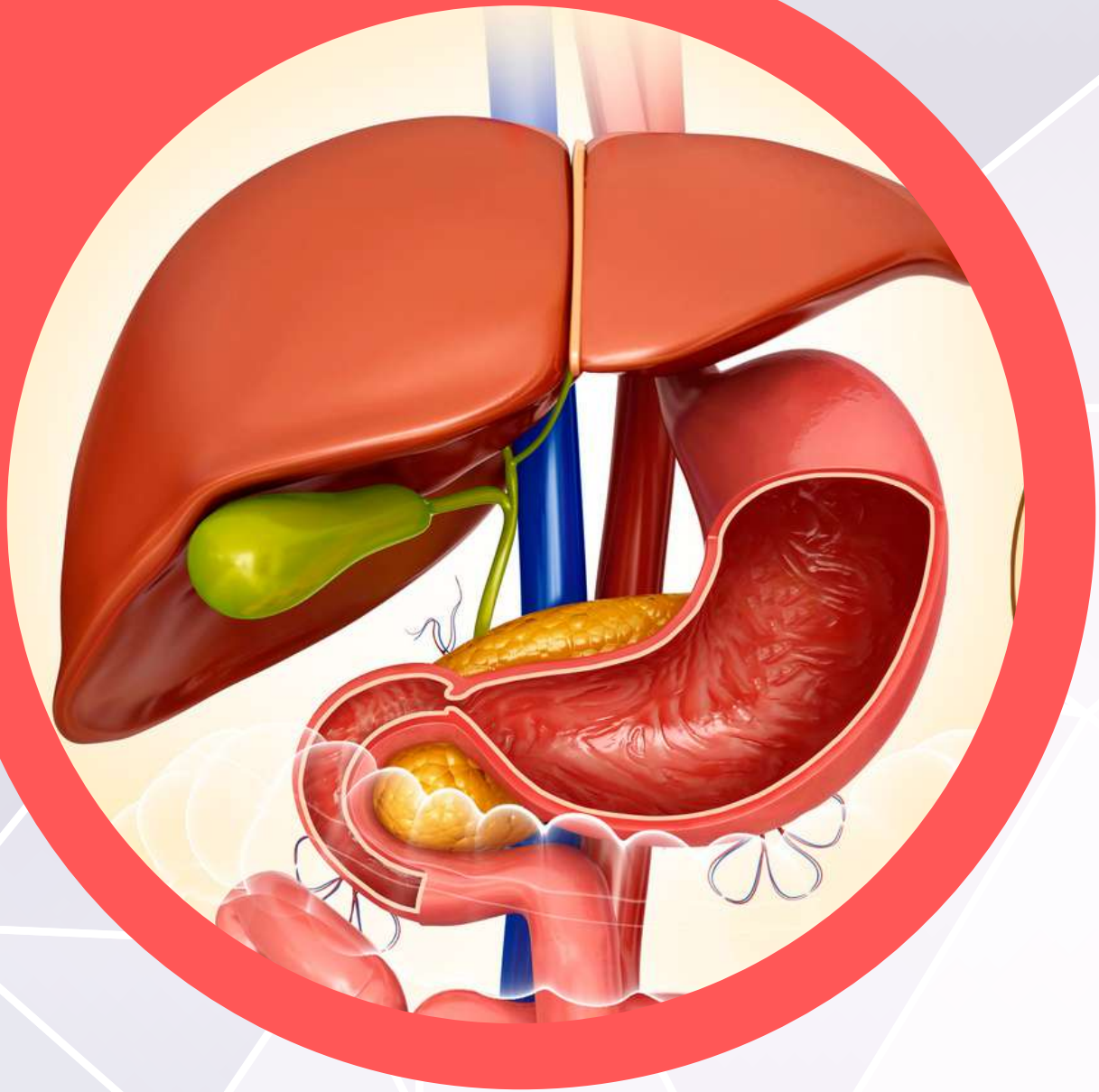
Review Break

- 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!

Label the heart diagram below (without looking back through your workbook!).





Digestive system

Digestive System - External Anatomy

Skeleton

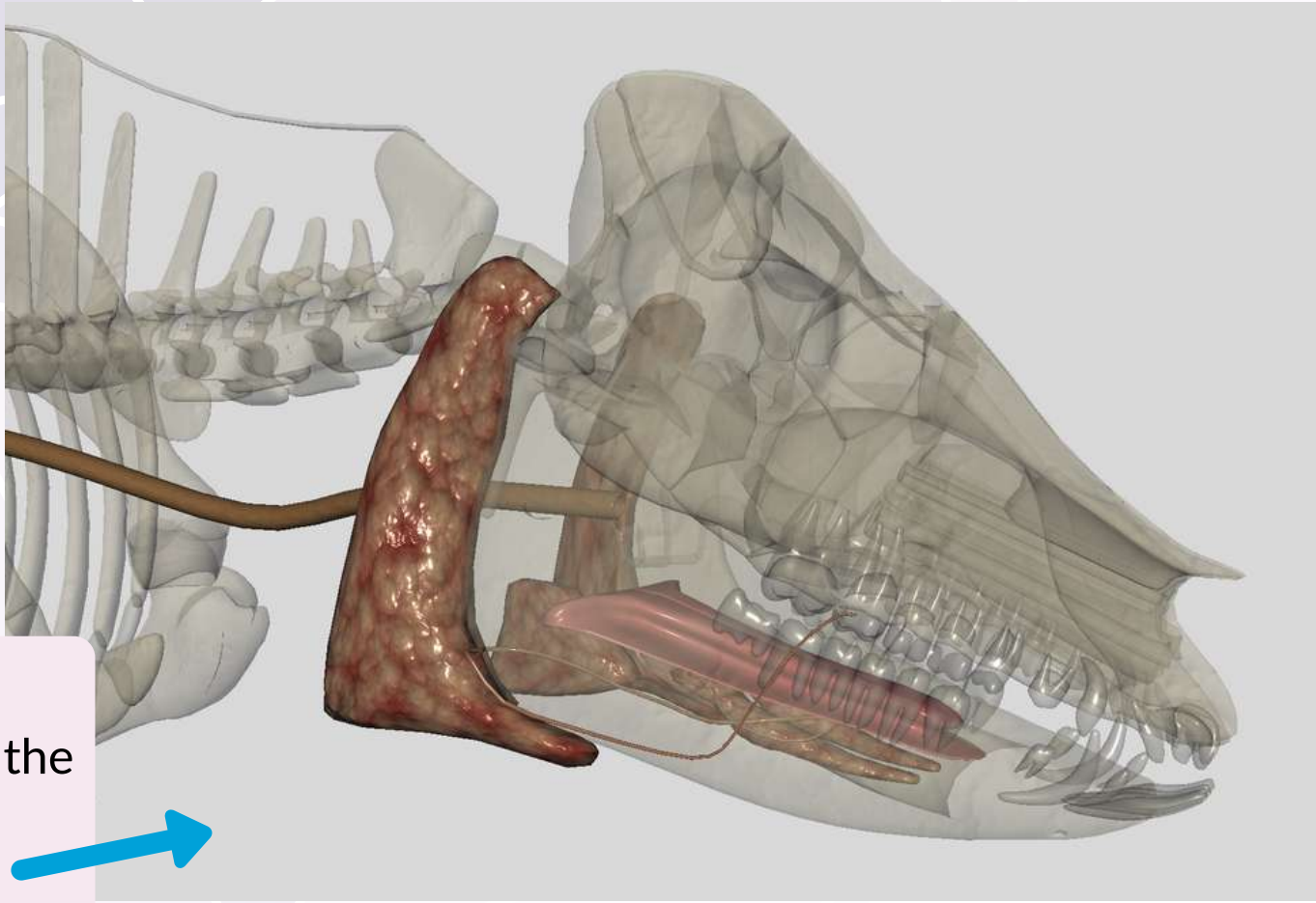
Digestive

Turn off all other body systems and focus on these

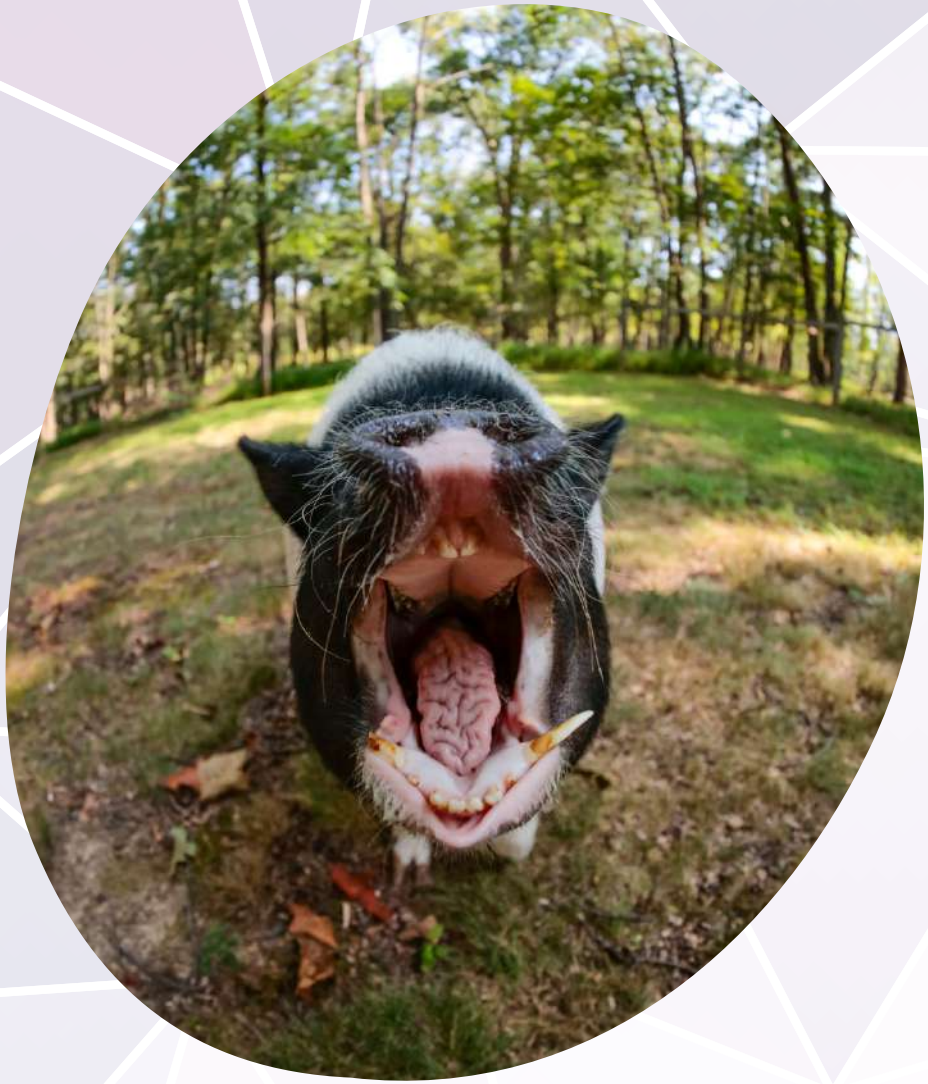
Rotate your pig and zoom in so that the head is visible

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

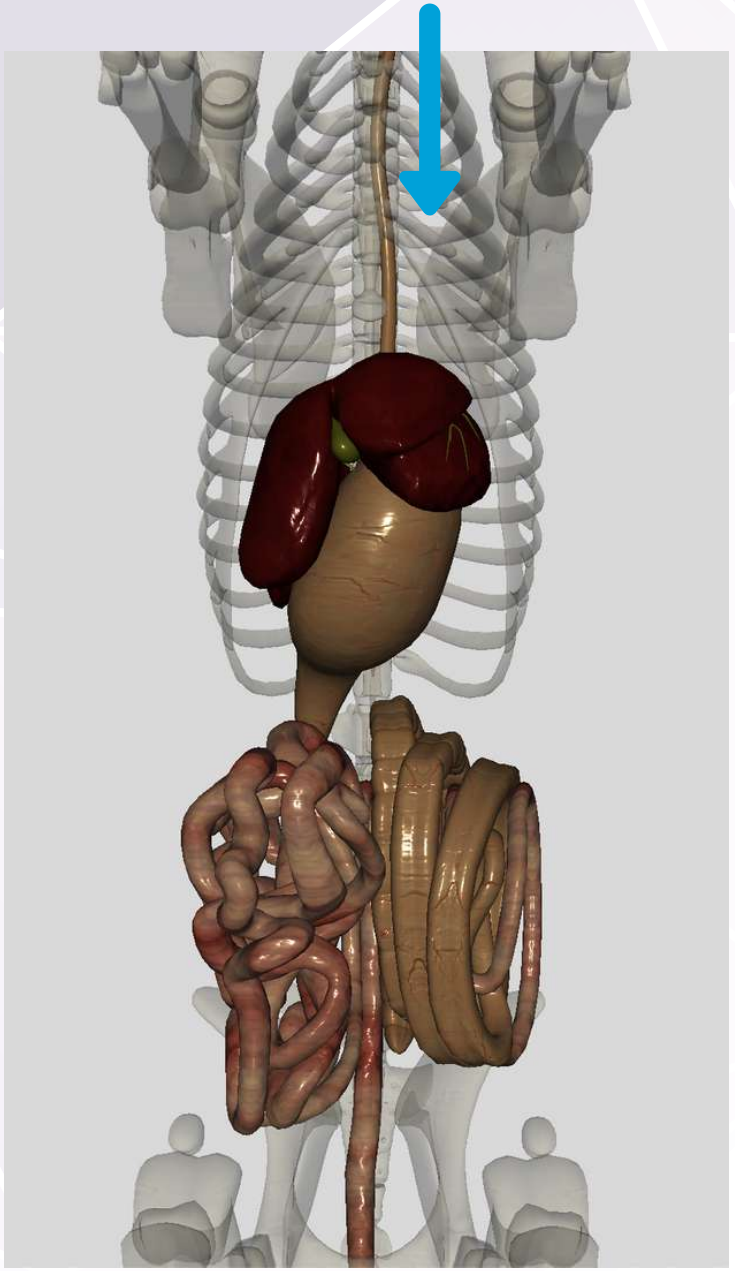
→ Normal diet consists of a variety of plant and animal material

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

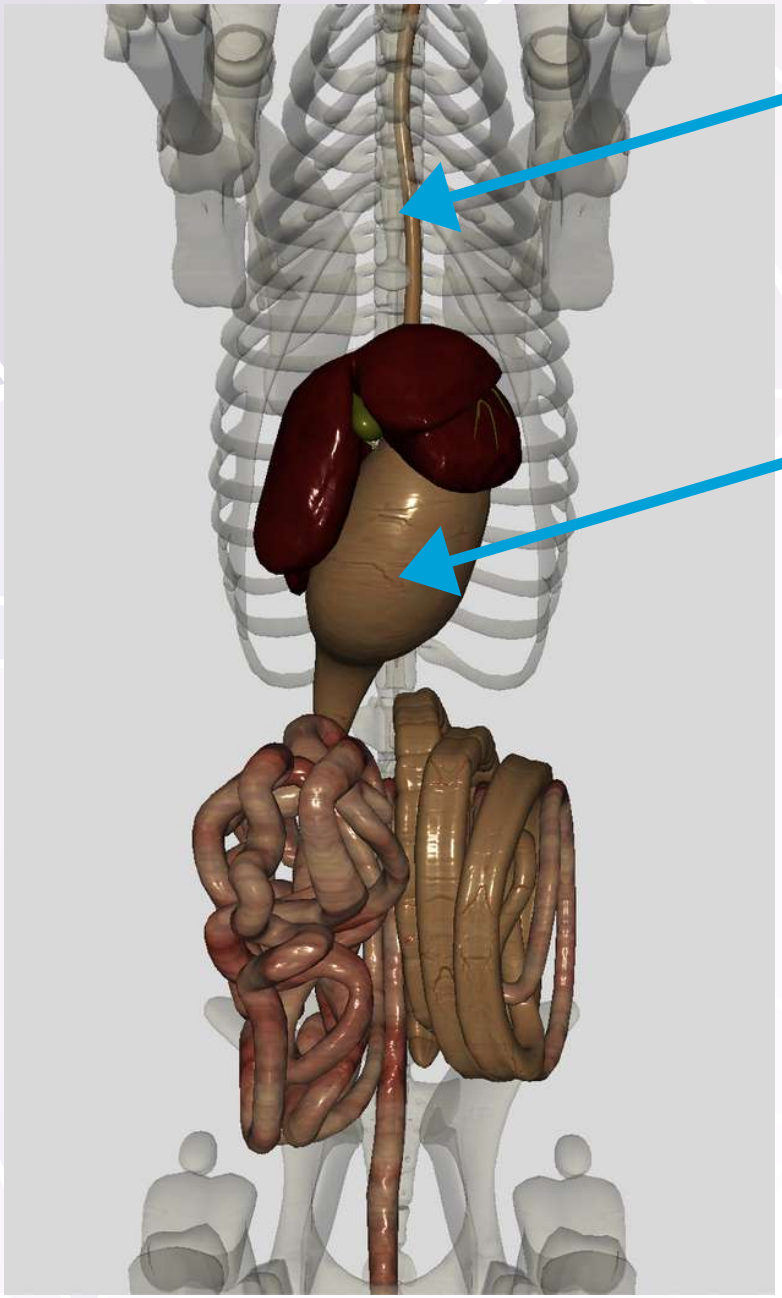
After mechanical and chemical digestion in the mouth, the chewed food (called a **bolus**) is swallowed

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

Food travels down esophagus towards stomach

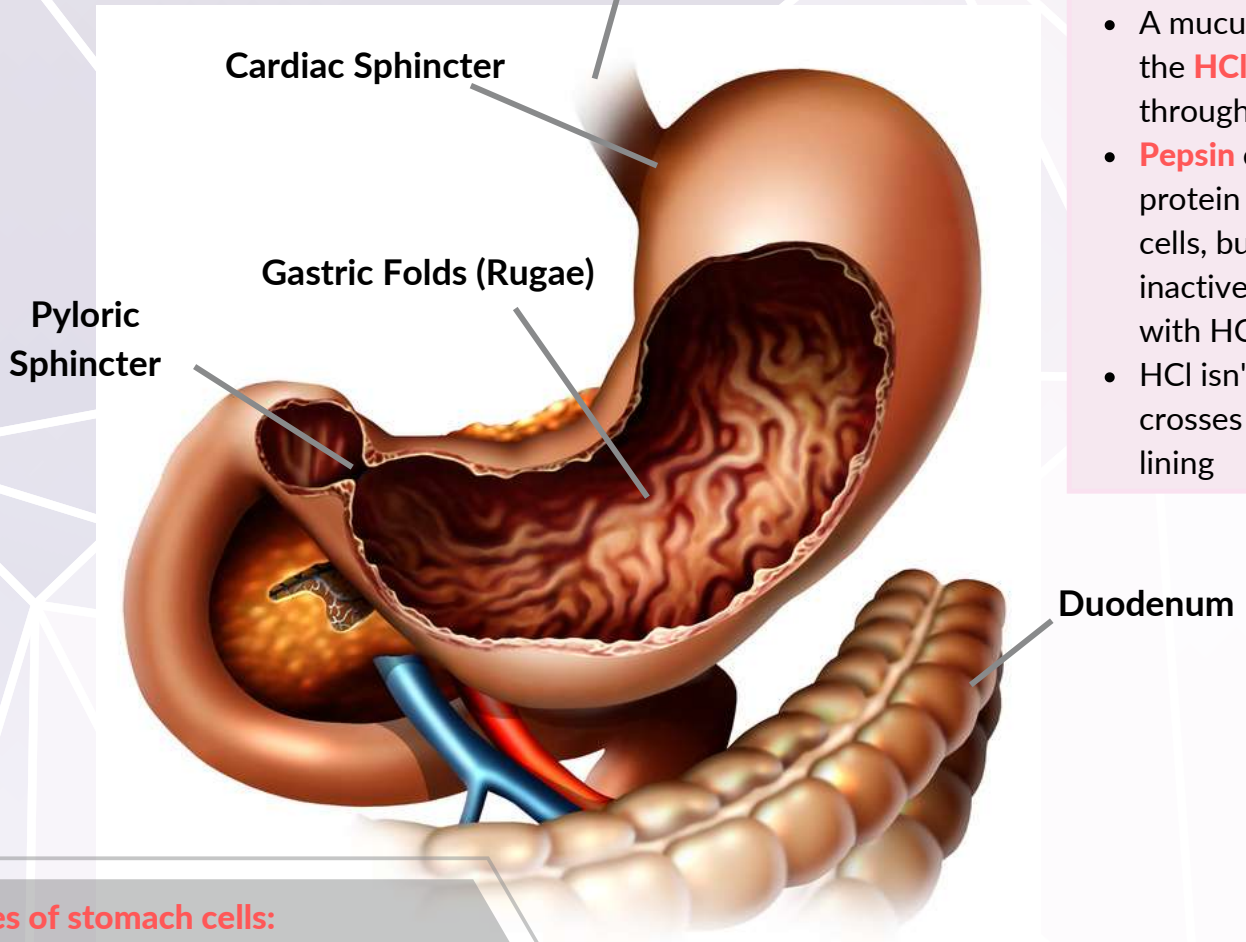


The bolus moves through the esophagus to the **anterior portion** of the stomach



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



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

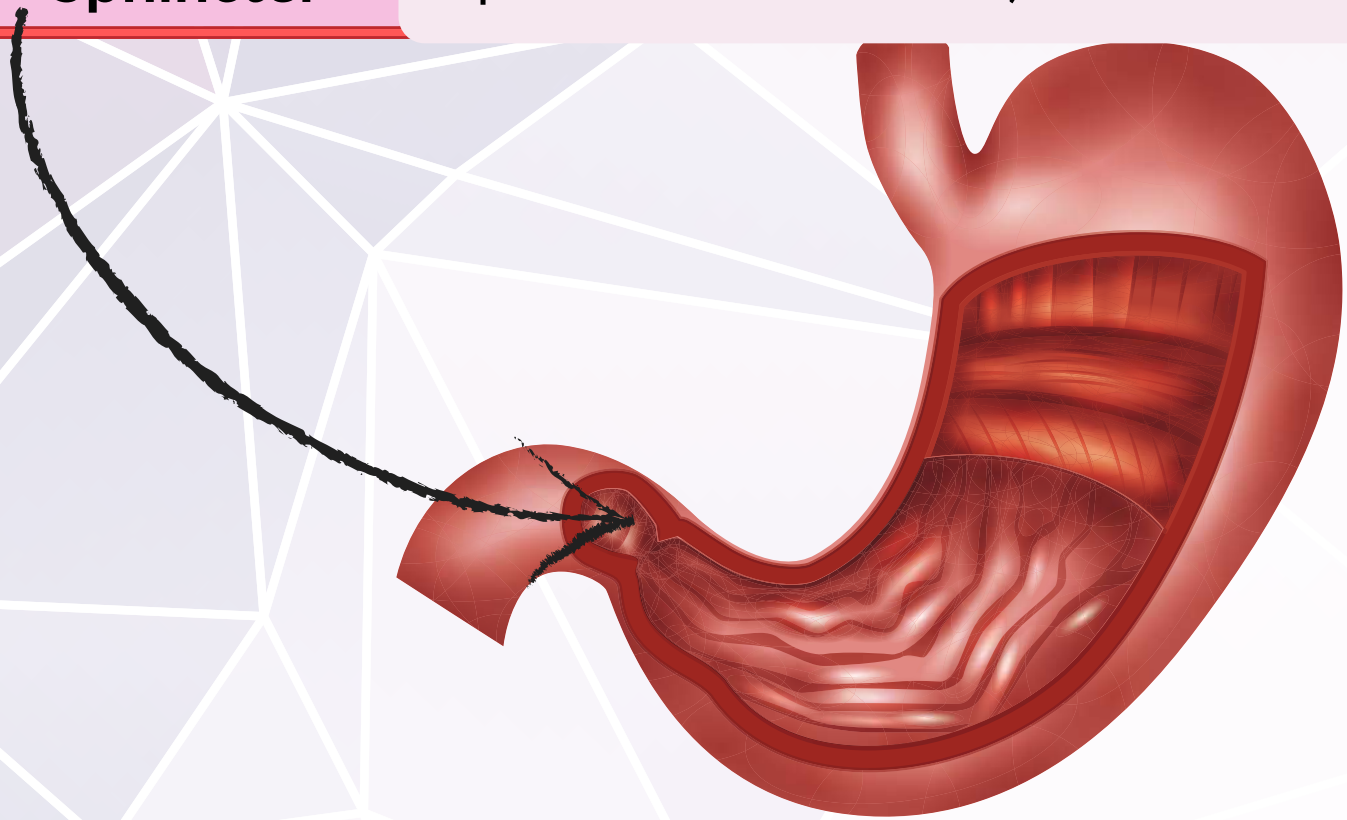
There are 3 types of stomach cells:

- **Mucus cells**: secrete protective coat
- **Parietal cells**: secrete **HCl** (pH 3) which 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

Pyloric Sphincter

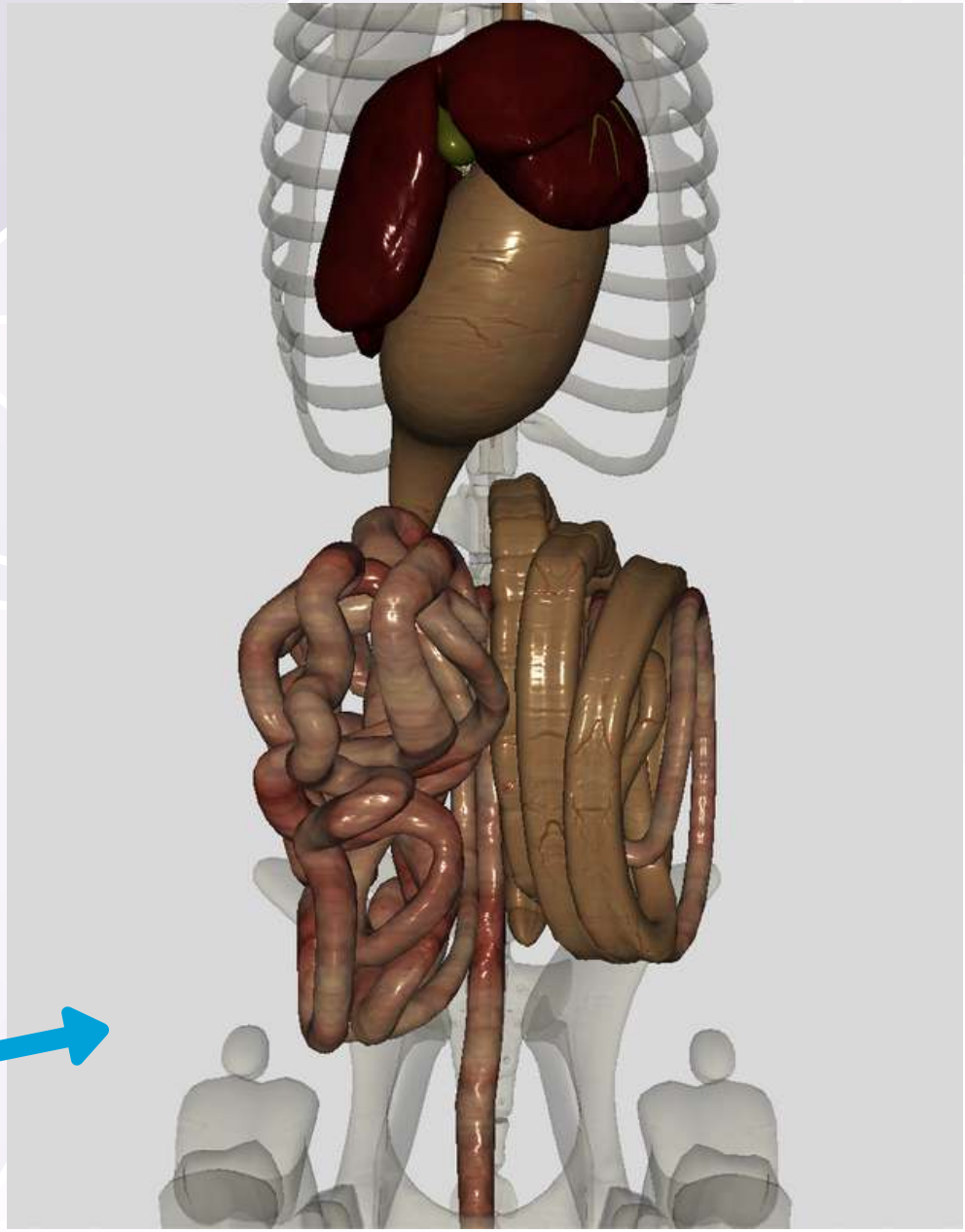
Valve between the stomach and duodenum (first part of small intestine)



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

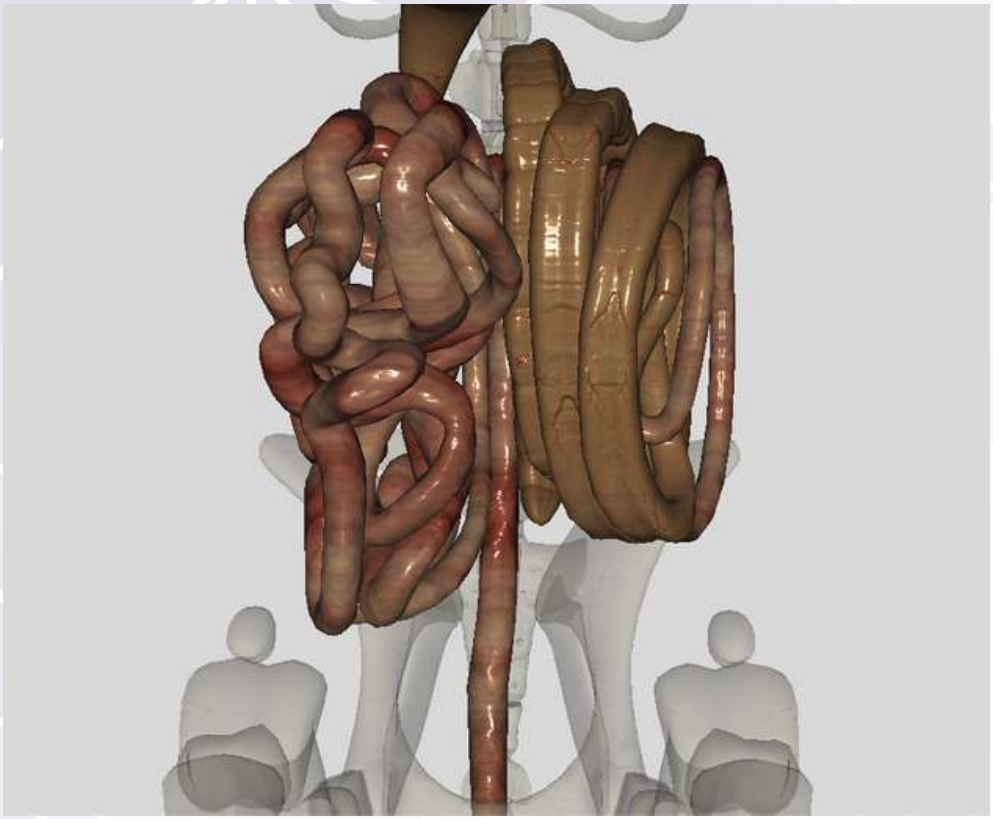
Locate and label the **jejunum** and **ileum**. These, along with **duodenum** make up the small intestines.

Can you label them on the image?



Small Intestine

- Location: slender coiled tube, starting at the **stomach**, and connects the **large intestine** at the **caecum**
- Structure: consists of **duodenum, jejunum, and ileum**, supported and wrapped by a membrane of **mesentery**



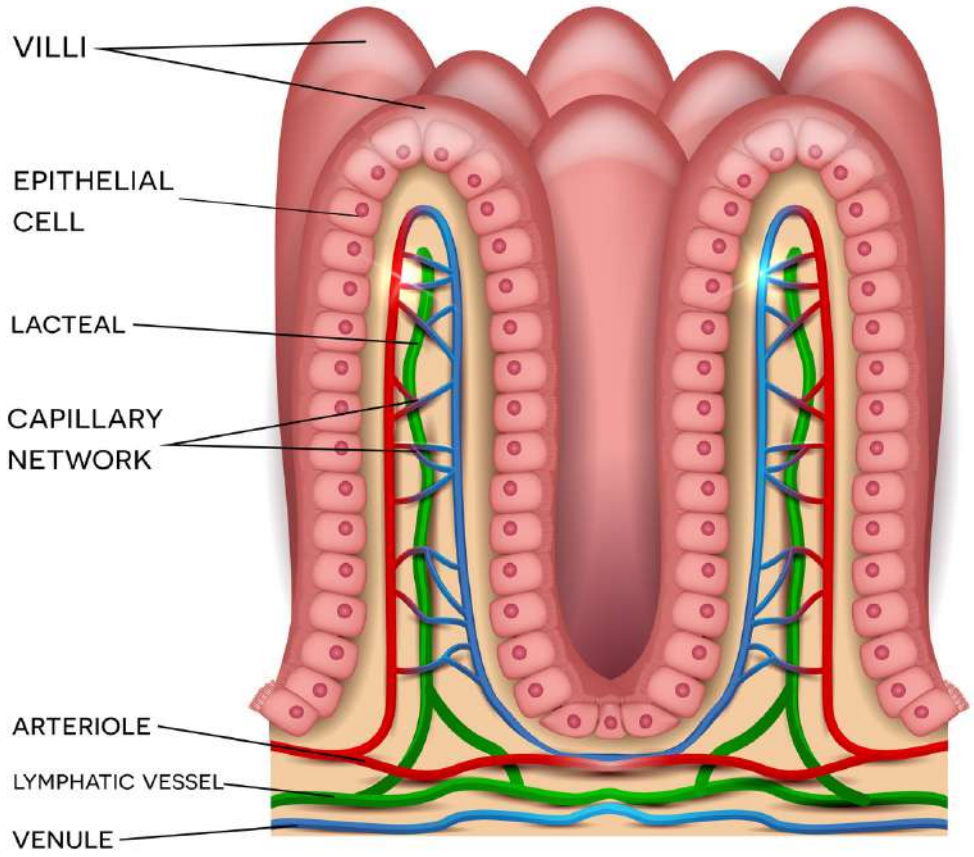
- Function: receives food from stomach
  - Completes **digestion** started earlier
  - Most food **absorption** and **chemical** digestion occurs here

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, more area for absorption

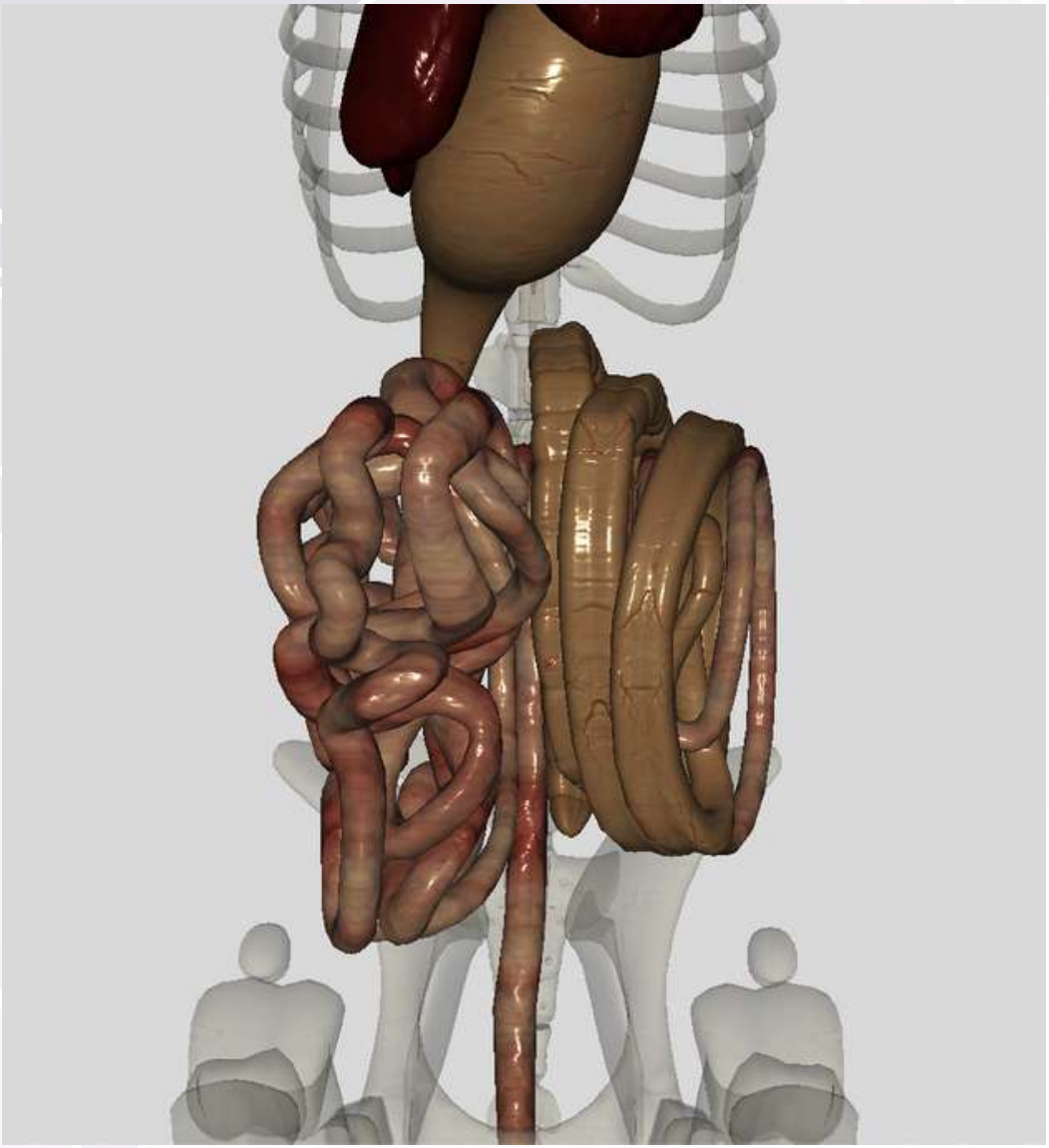
You won't see villi on the 3D Pig Anatomy App, but they are there - we promise!



Large 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)



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

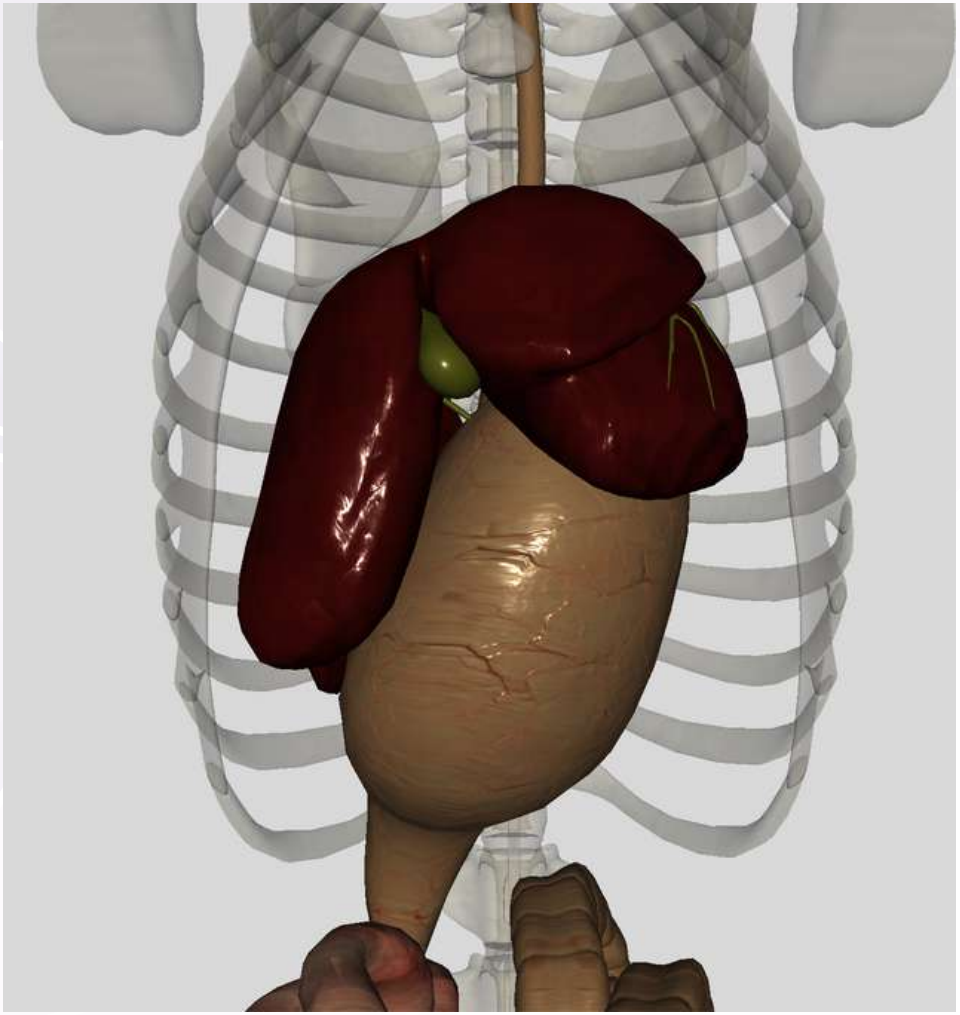
- **Caecum** - contains microorganisms which help **breakdown plant material** not digested by enzymes in small intestine.

Why would some carnivores have a very small or sometimes non-existent caecum?

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

Liver

- Location: ventral & anterior to the **stomach**
- Structure: dark red/brown wedge-shaped organ with **4 lobes**
- Function: multipurpose organ
  - Produces bile
  - Removes toxins
  - Stores carbs
  - Regulates blood sugar levels



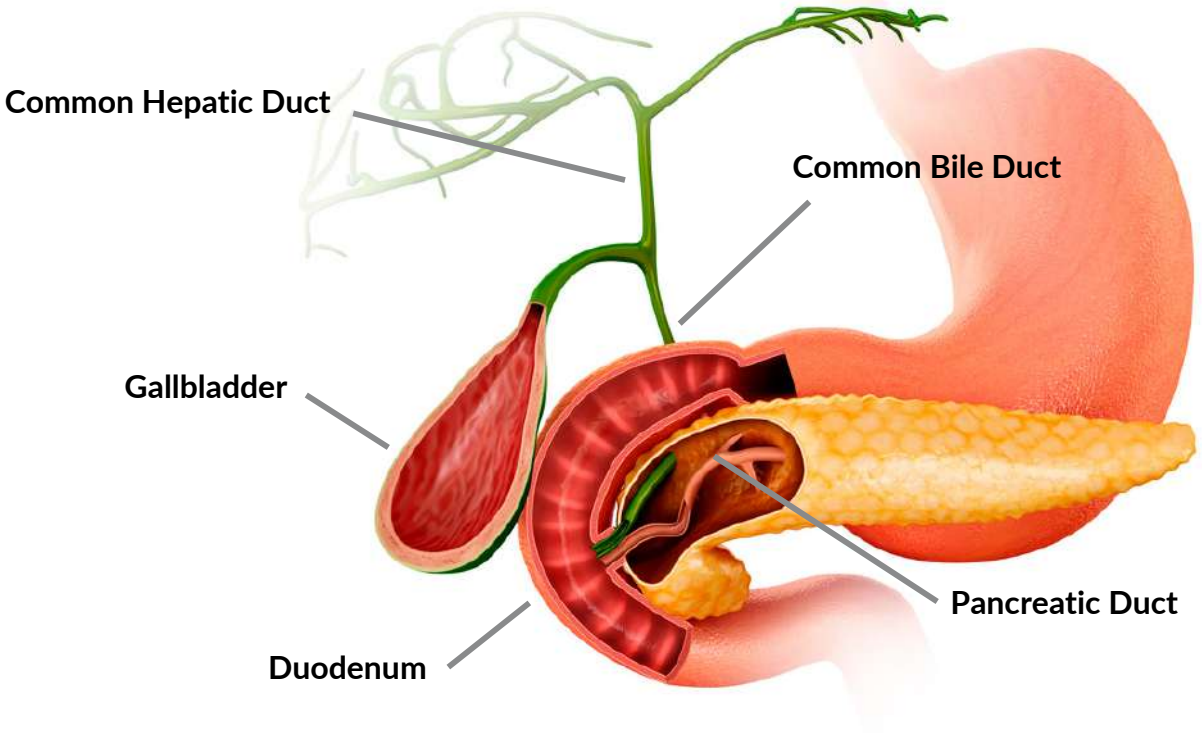
Pancreas

Exocrine Functions: cell secretions are released into a duct

- **Produces bicarbonate ions (HCO3).**
  - These neutralize stomach acids and make pH of intestine 7-8 (alkaline).
  - released through pancreatic duct. Small intestine enzymes are optimum at basic pH
- **Produces digestive enzymes:** amylases, peptidases, lipases, and nucleases
  - 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)
- This 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

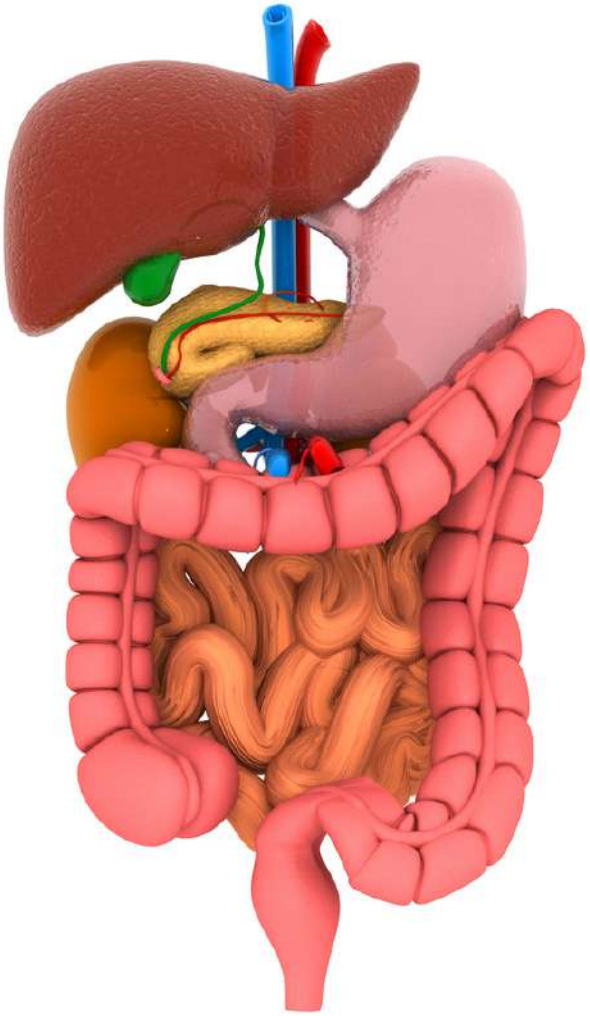
Review Break

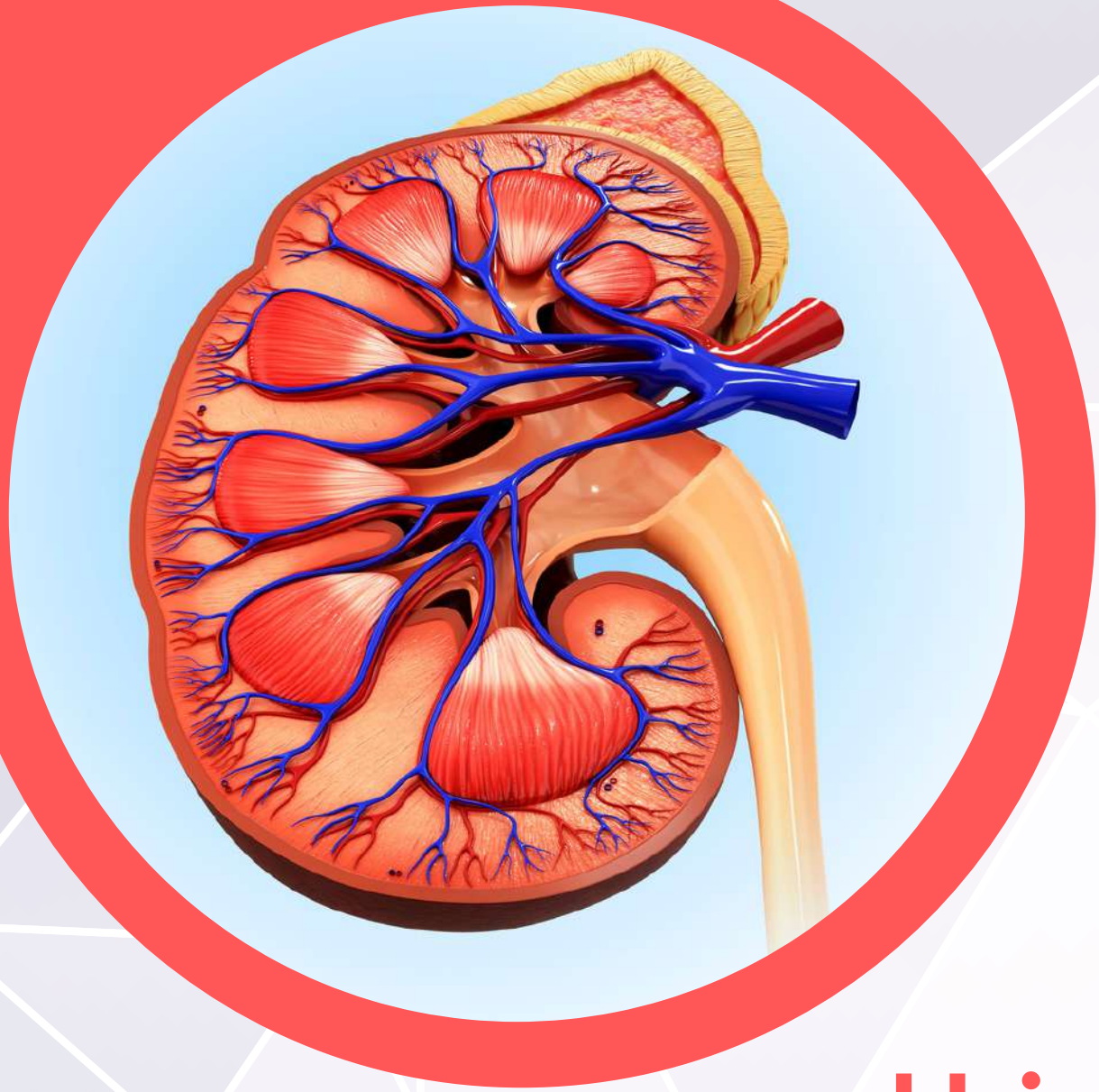
- With your group, trace the path of food through the digestive system. Name all the different structures the food passes through from the moment a pig takes a bite, to the moment it poops!

- Choose one person to explain it to the class.

QUIZ!

Label the digestive system diagram below (without looking back through your workbook!).





Urinary system

See Endocrine System for details of reproductive organs

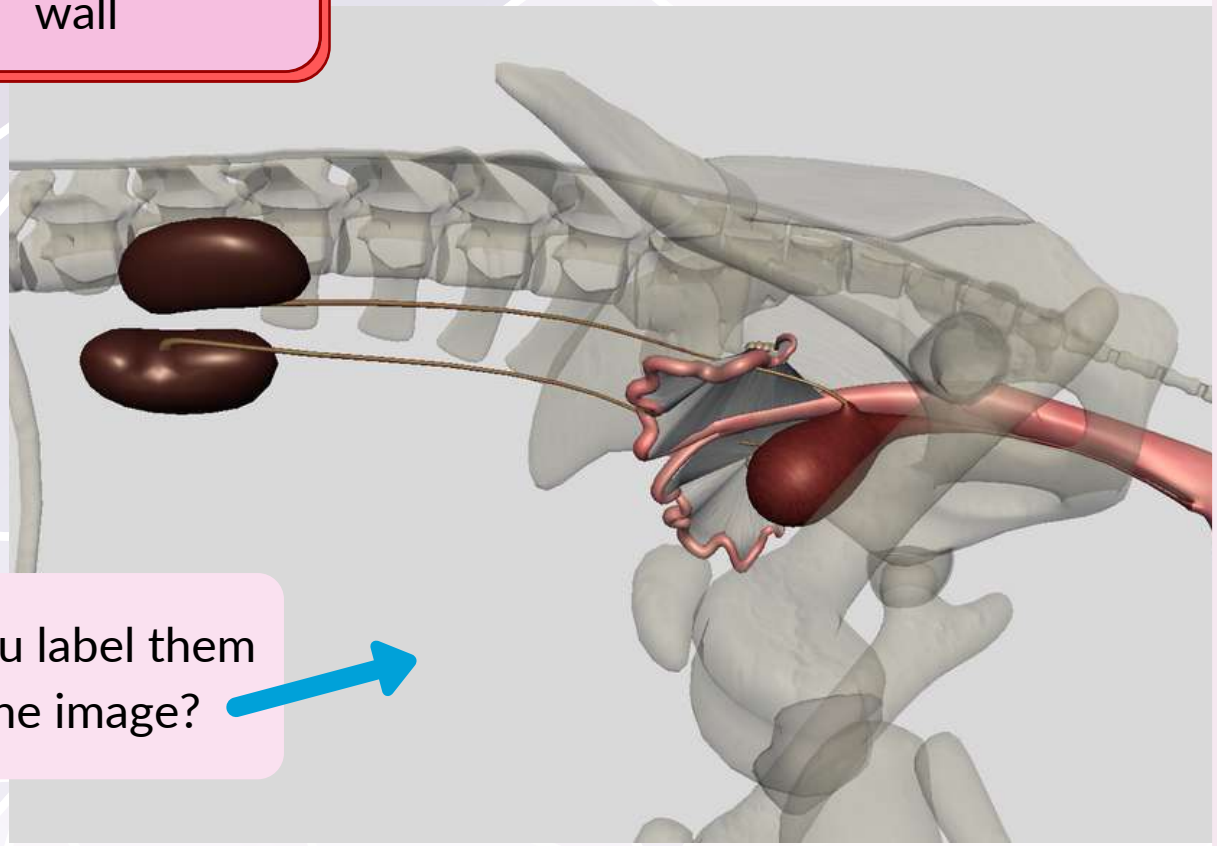
The Kidneys

Turn off all other body systems and focus on these

Skeleton

Urogenital

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



Can you label them on the image?

Kidneys

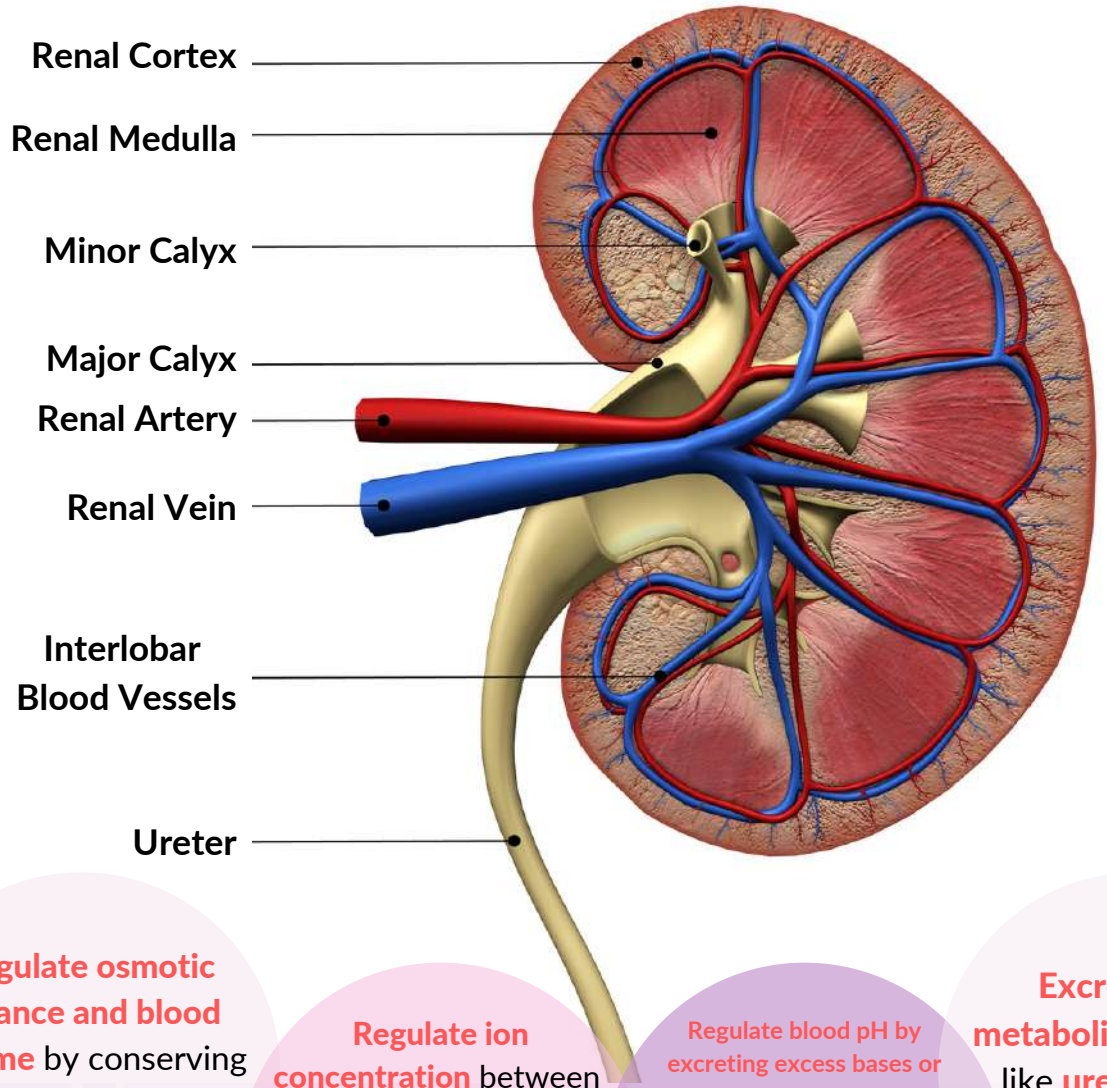
Location: high in abdominal cavity, one on each side of the spine

Structure: bean-shaped, surrounded by tough fibrous tissue

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

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 H20 as demanded by the situation

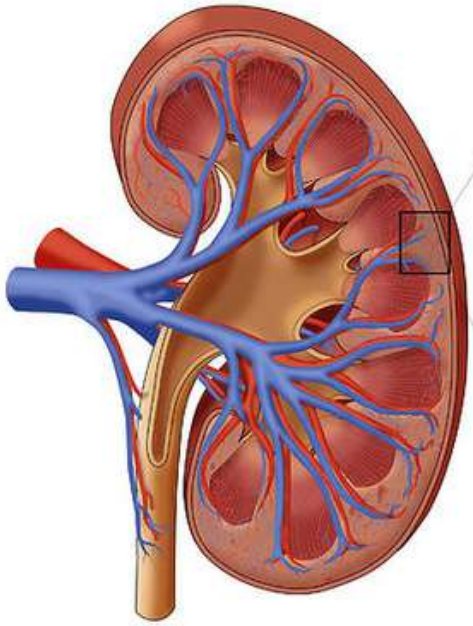
Regulate ion concentration between the extracellular fluid (ECF) and the blood by controlling the excretion of inorganic **salts**

Regulate blood pH by excreting excess bases or acids:

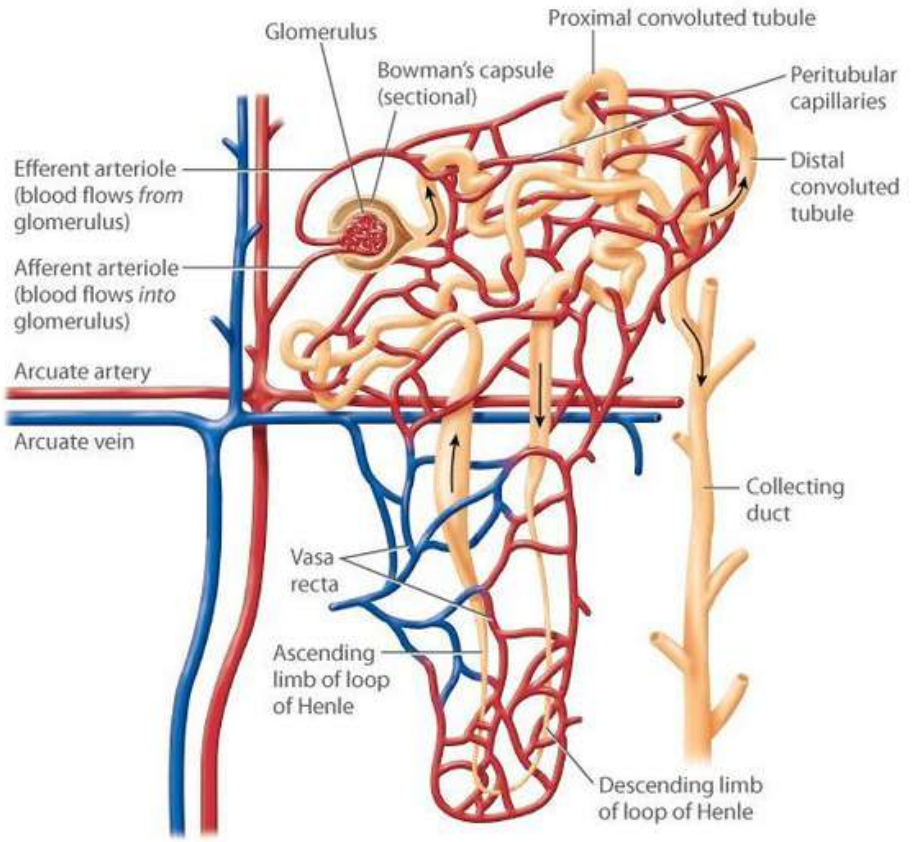
- H^+ is excreted and HCO3- is reabsorbed if **blood is acidic**
- H^+ is **NOT** excreted and HCO3- is **NOT** reabsorbed if **blood is basic**

Excretes toxic metabolic by-products like **urea**, ammonia, uric acid, and creatinine

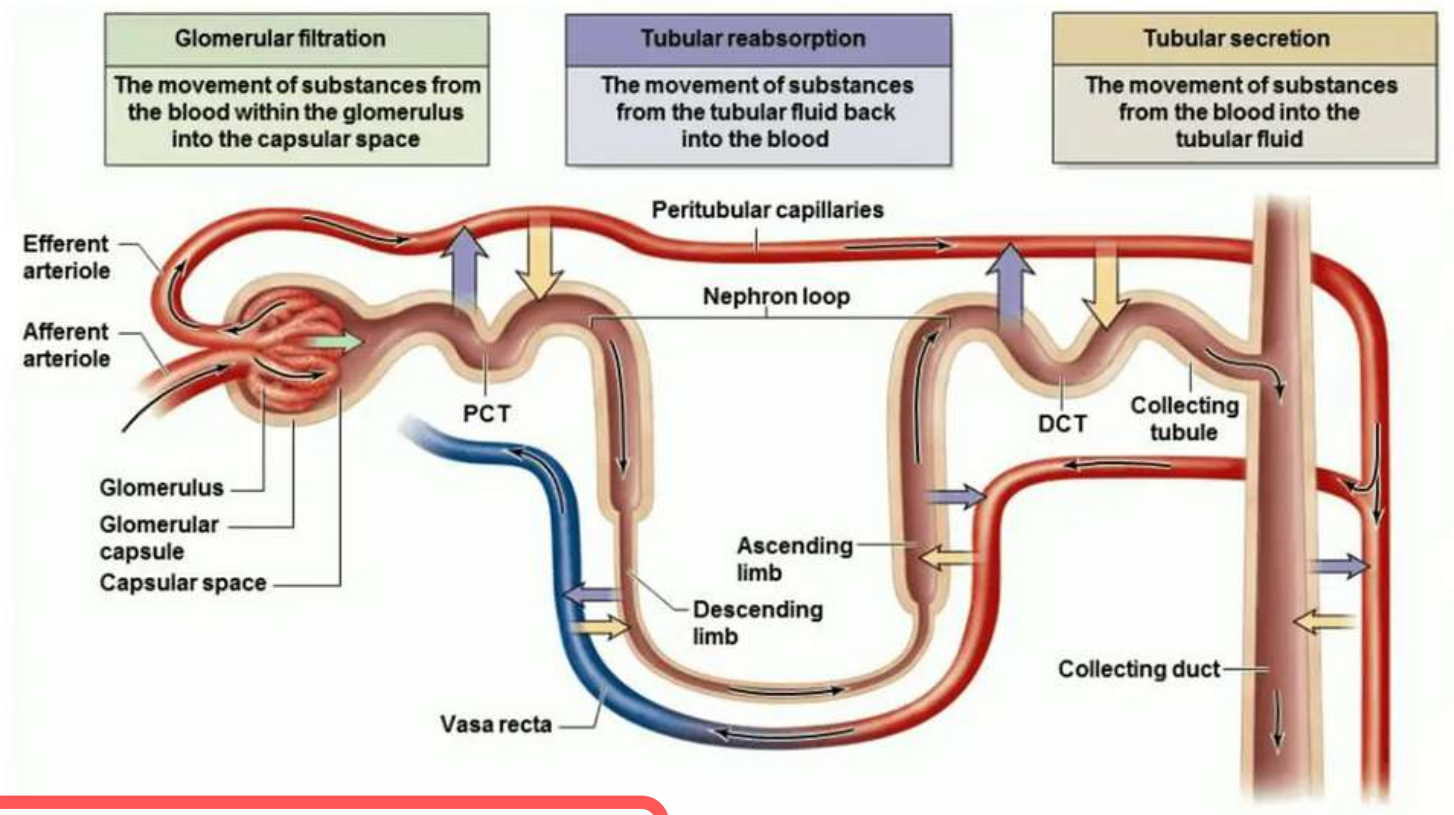
The **nephron** is the functional unit of the kidney.
It consists of a **renal tubule** and its associated blood vessels.



Nephron



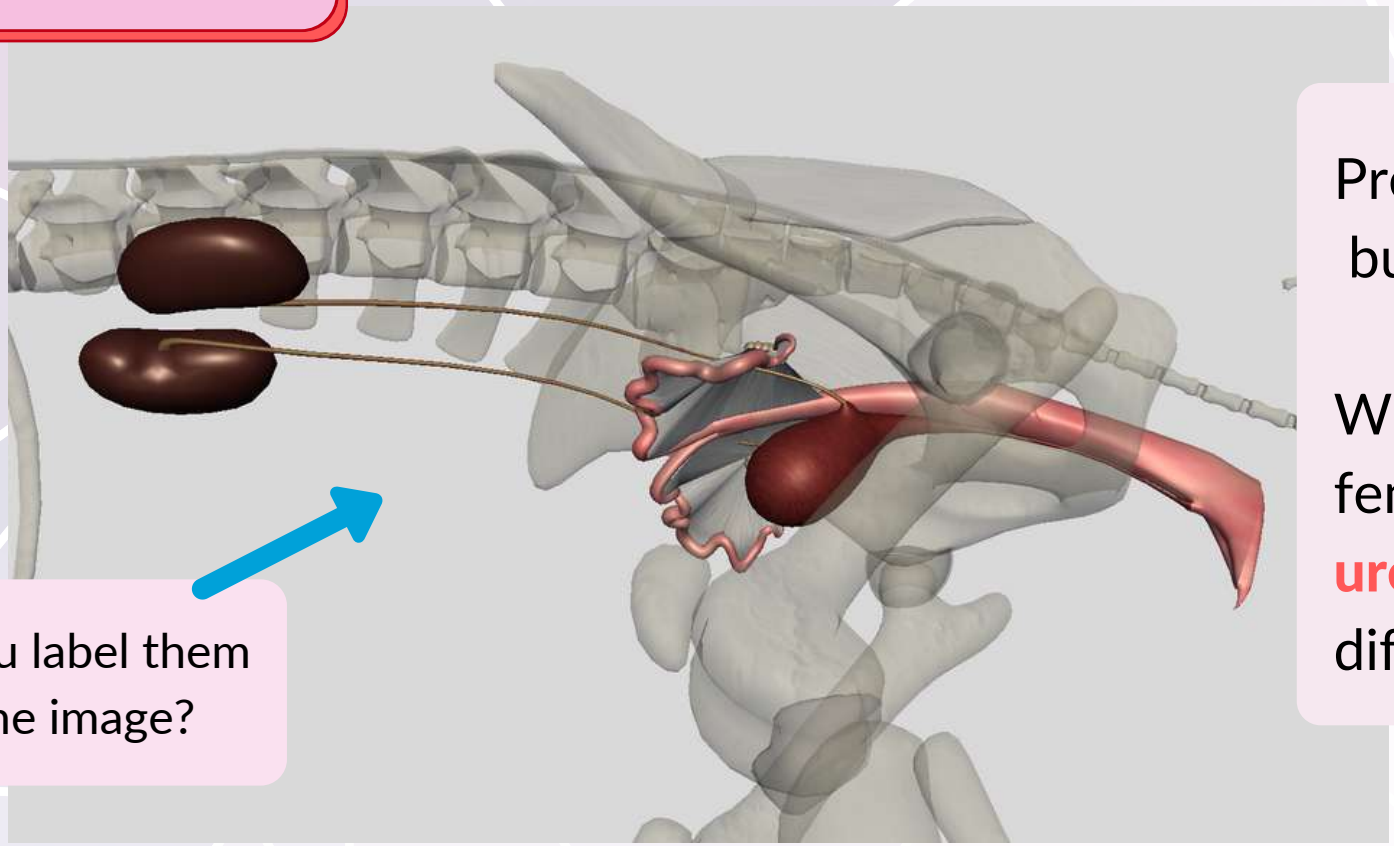
Urine Formation



Check Your Understanding

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

Locate the **ureter** and **urinary bladder**



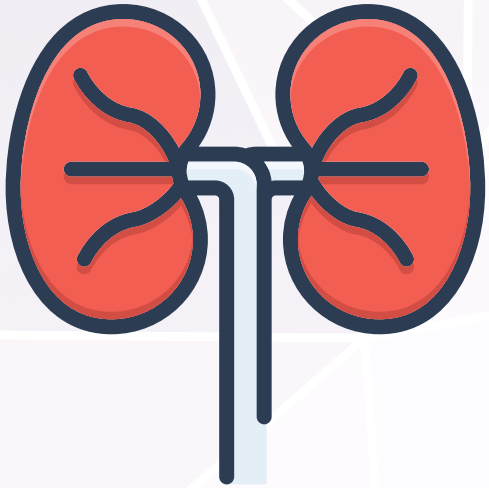
Can you label them on the image?

Press the button.

Why do you think the female and male **urethras** are different?

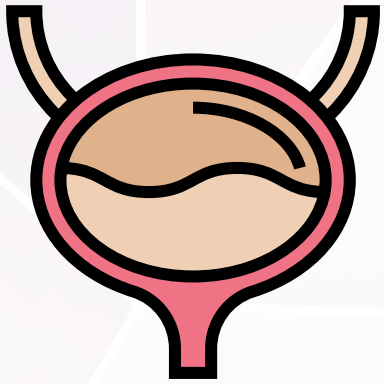
Also locate the **urethra**

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 in 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

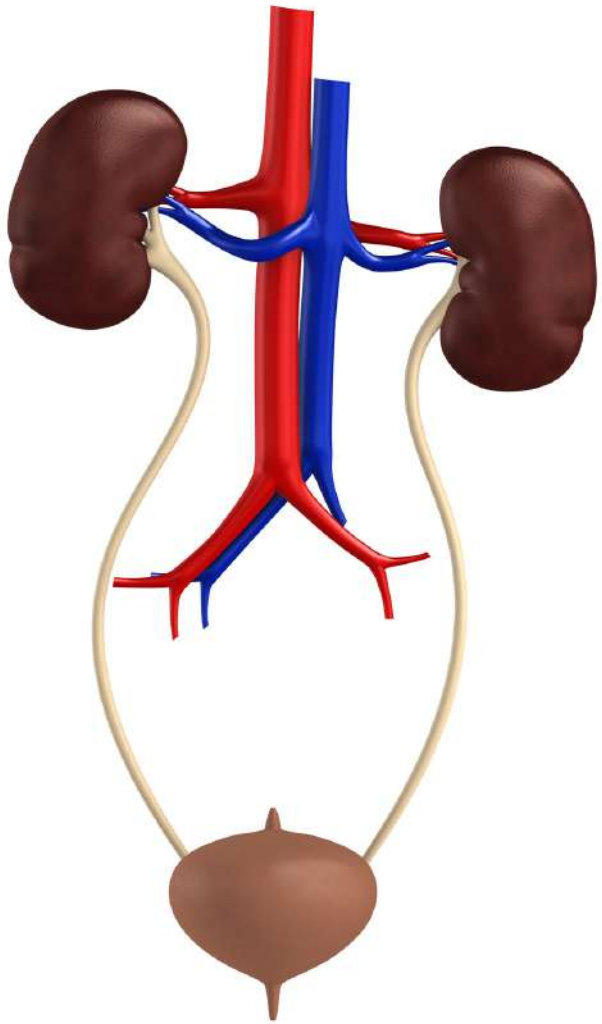
Review Break

- 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!

Label the urinary system diagram below (without looking back through your workbook!).



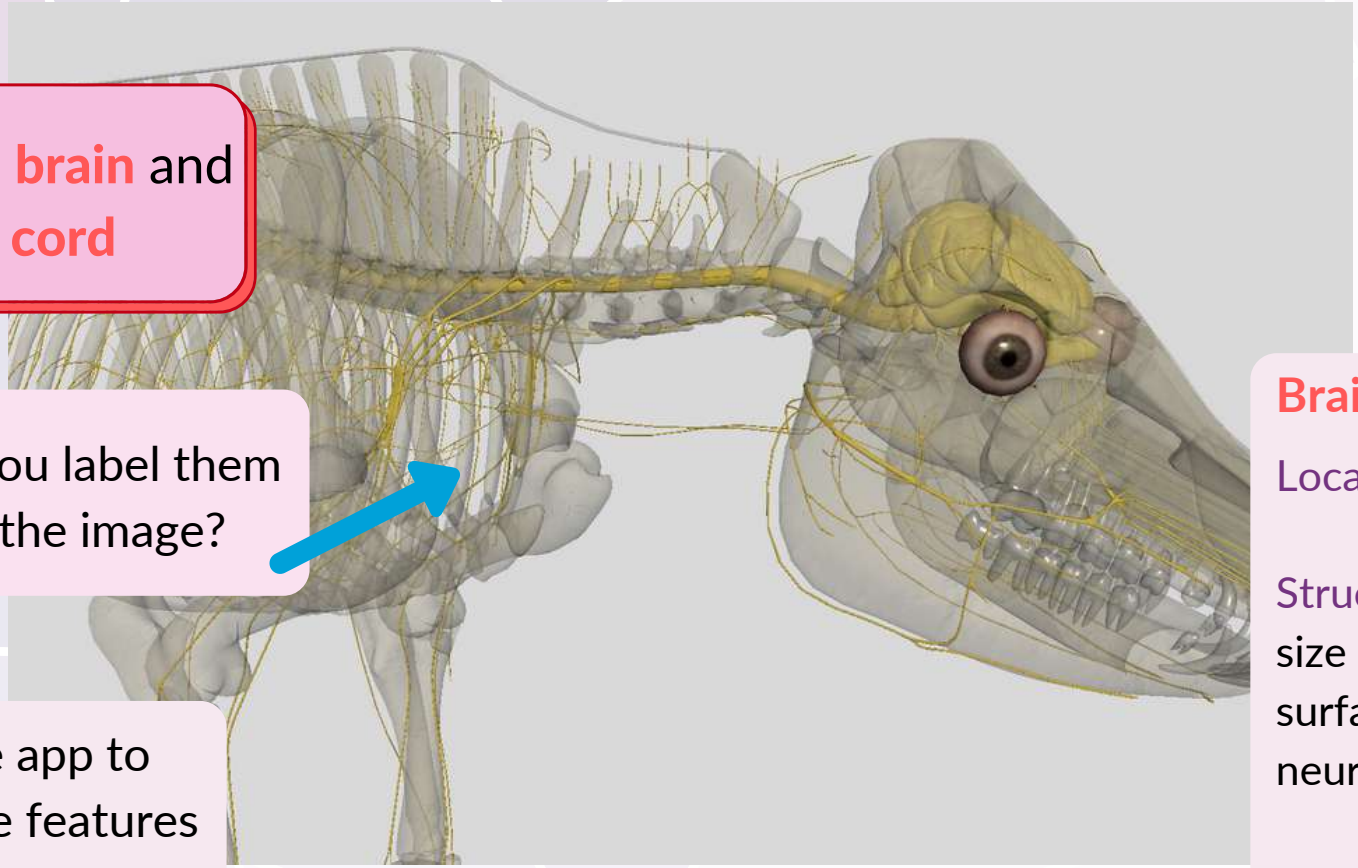
Nervous system

Central Nervous System

Turn off all other body systems and focus on these

- Skeleton
- Nervous

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



Can you label them on the image?

Use the app to label more features of the nervous system!

Brain

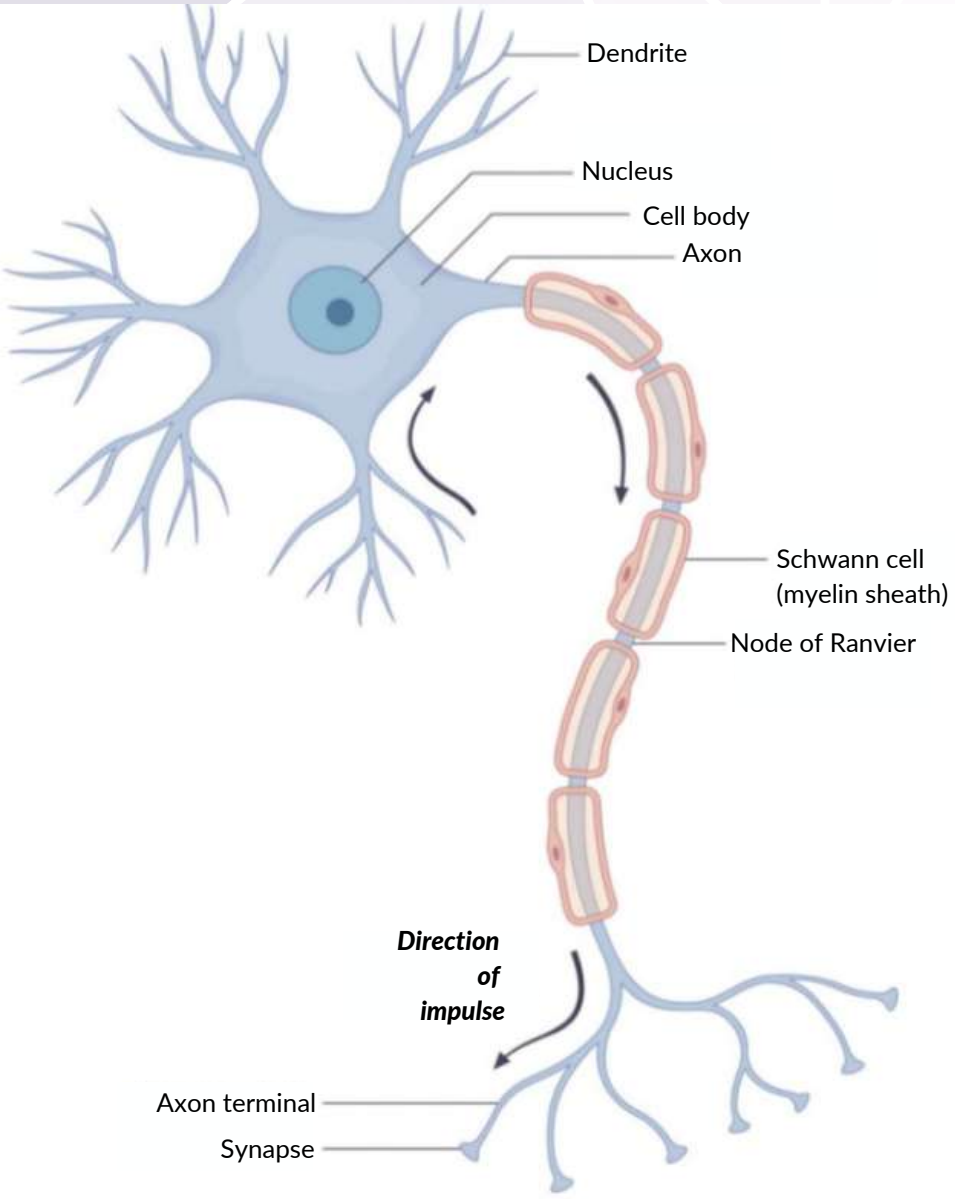
Location: in the skull

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

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

Nerves

Nerves are bundles of **neurons** (like the one pictured to the right) 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. Pretty cool, eh?!

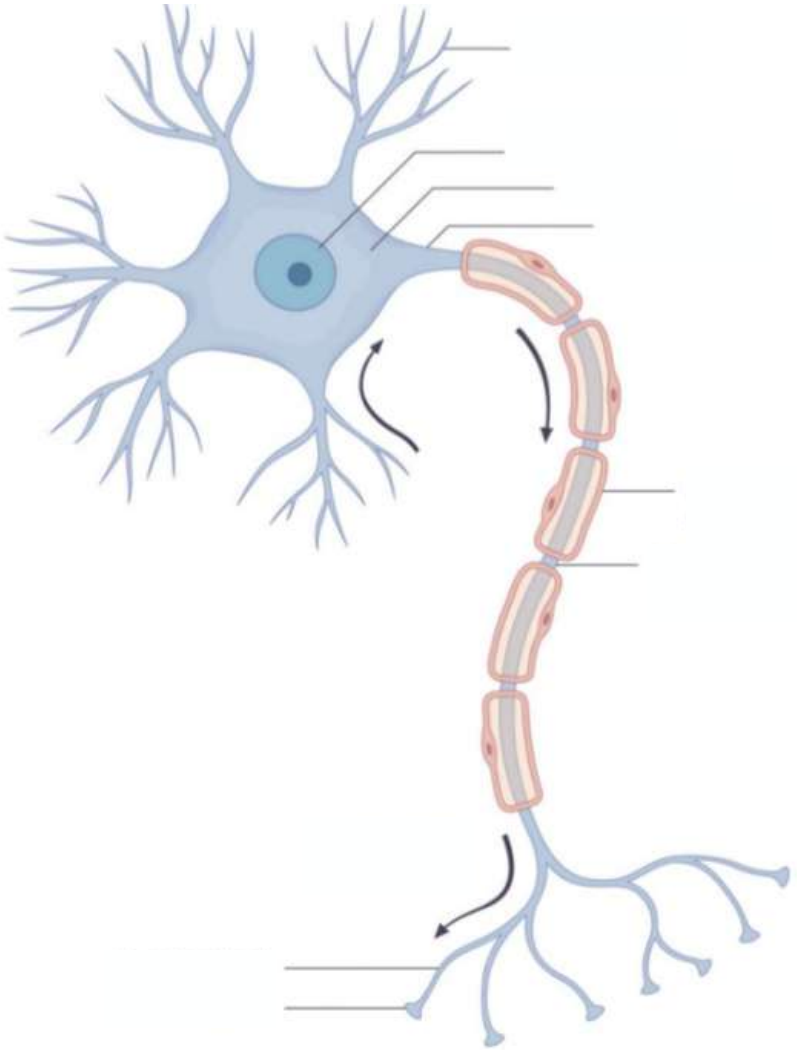


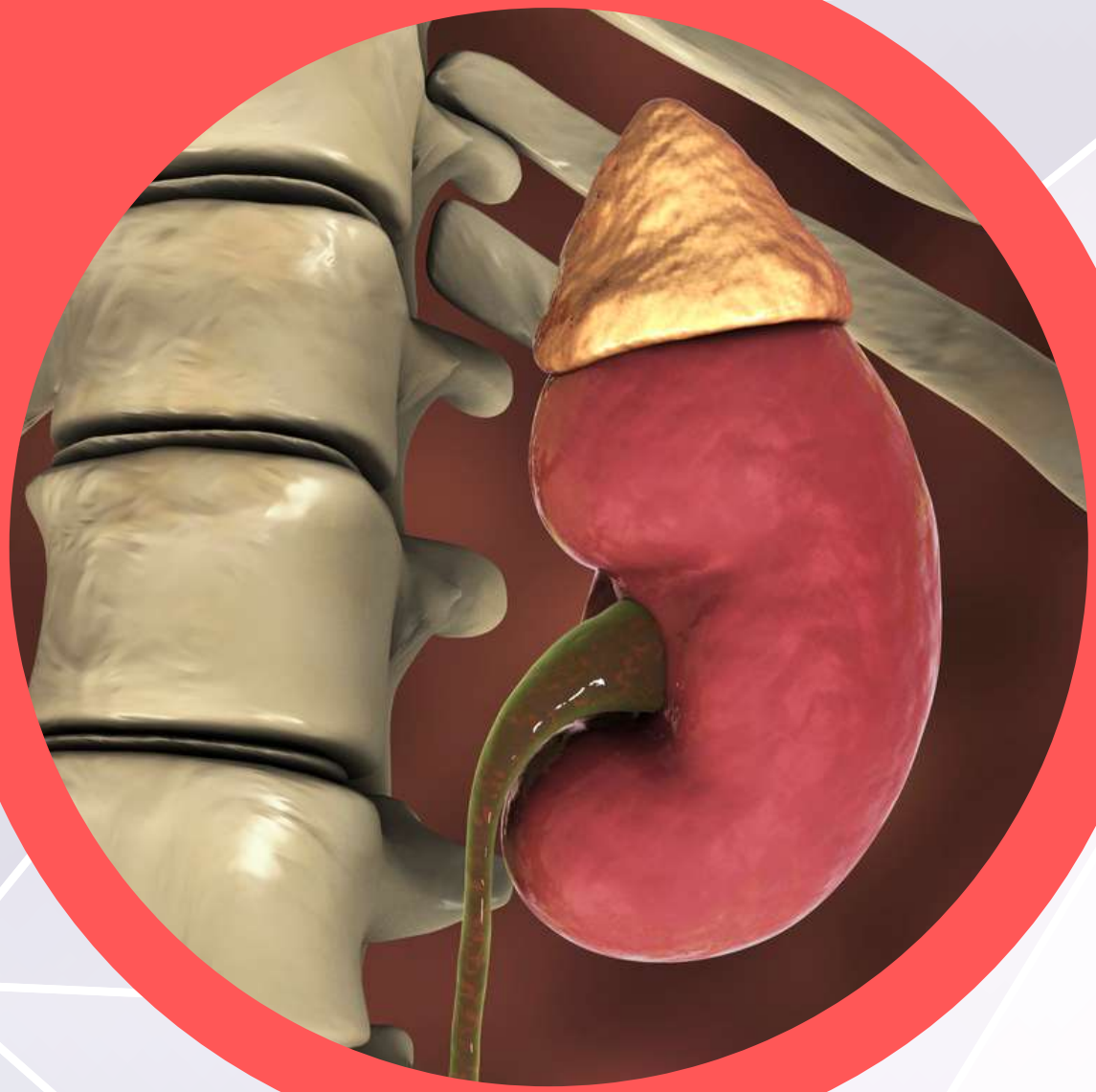
Review Break

- 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!

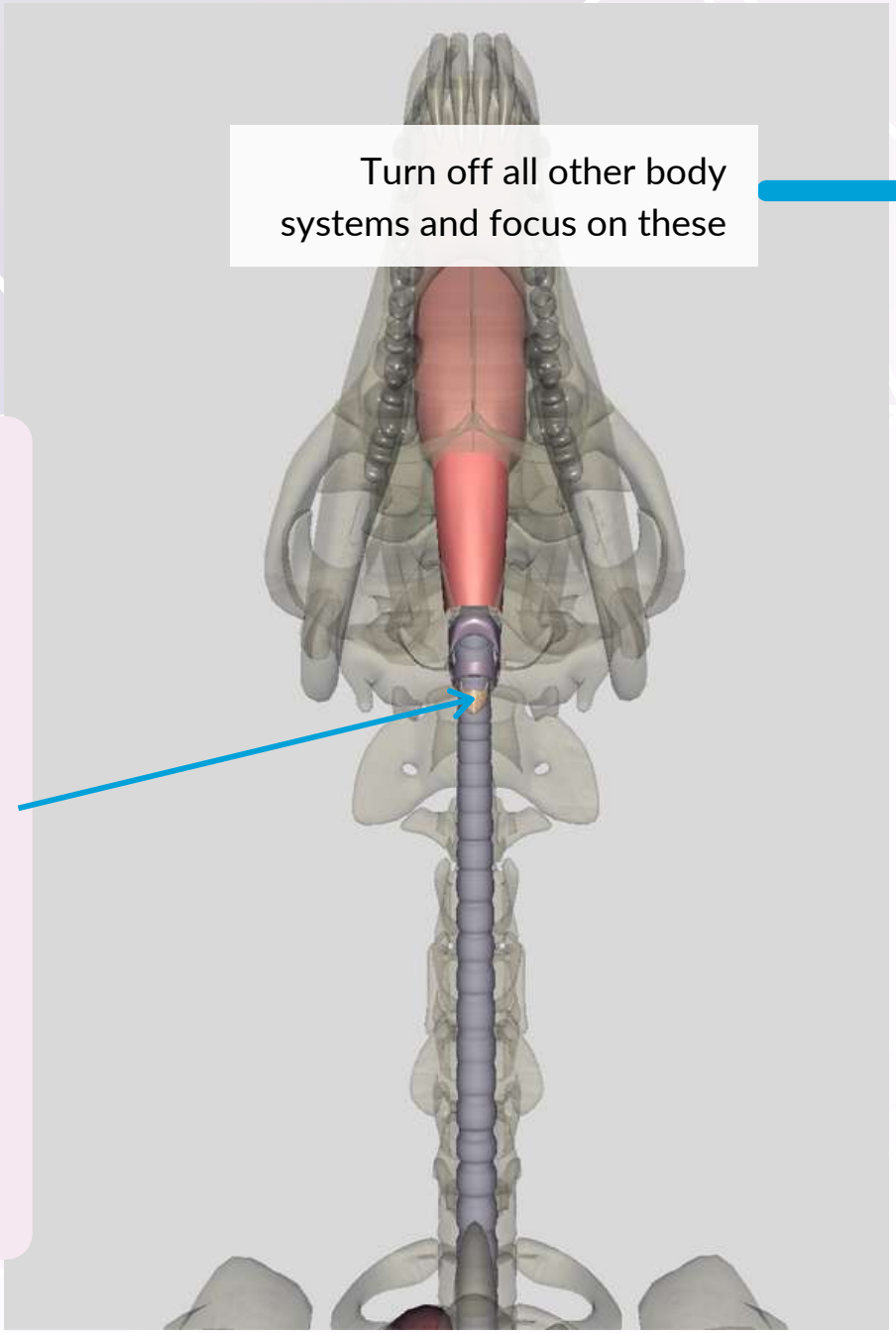
Label the nerve cell diagram below (without looking back through your workbook!).





Endocrine system

Thyroid



Thyroid

Location: around the trachea in the throat area

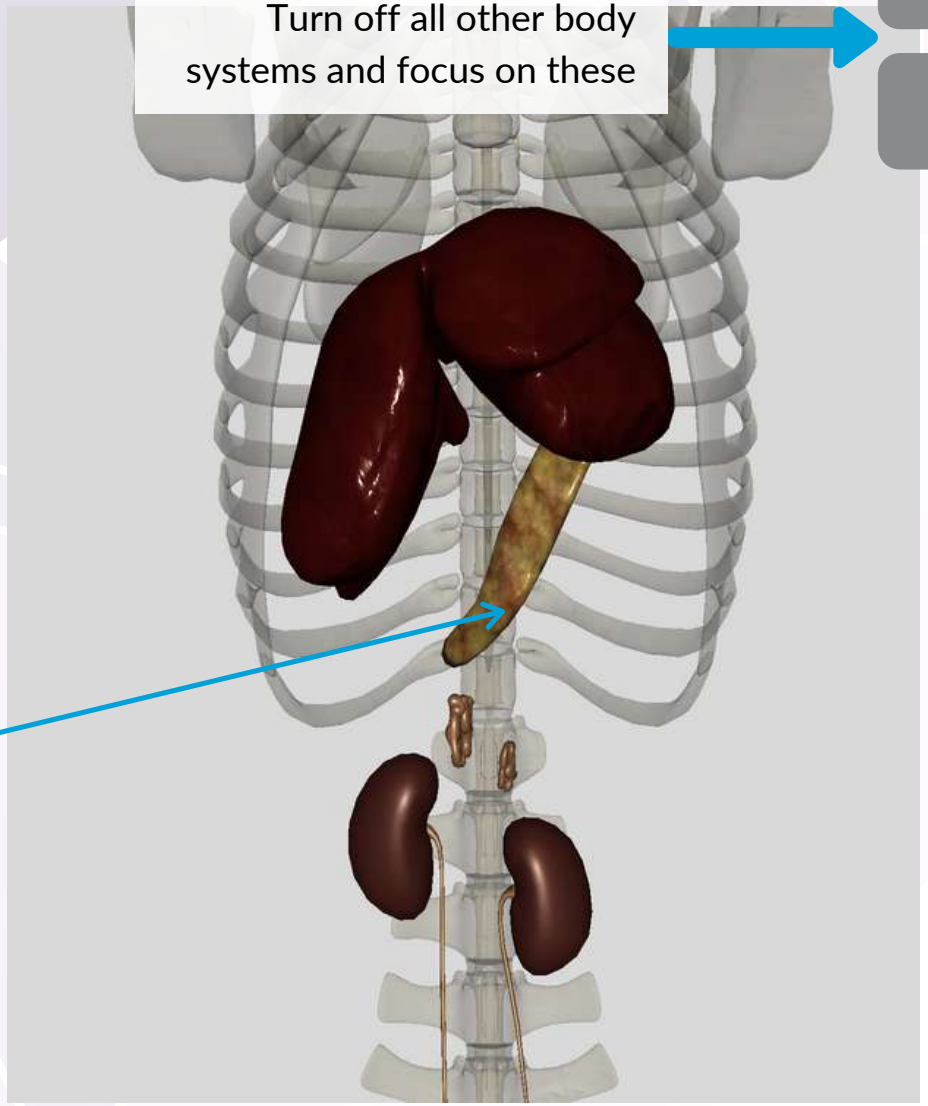
Function: produces hormones that **regulate the body's metabolic rate** controlling heart, muscle and digestive function, brain development and bone maintenance.

Pancreas

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).

Adrenal Glands

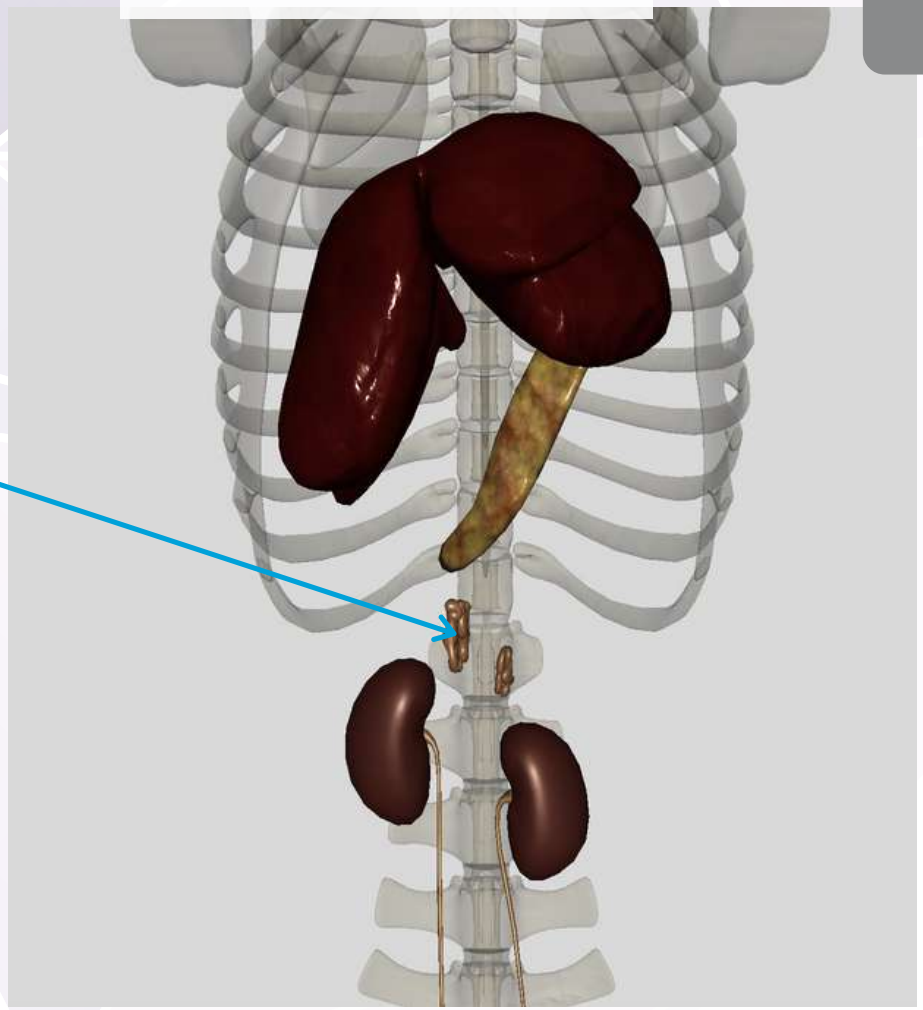
Turn off all other body systems and focus on these

- Skeleton
- Endocrine

Adrenals

Location: anterior end of kidneys

Function: produce **adrenaline** and **cortisol** (the stress hormone)

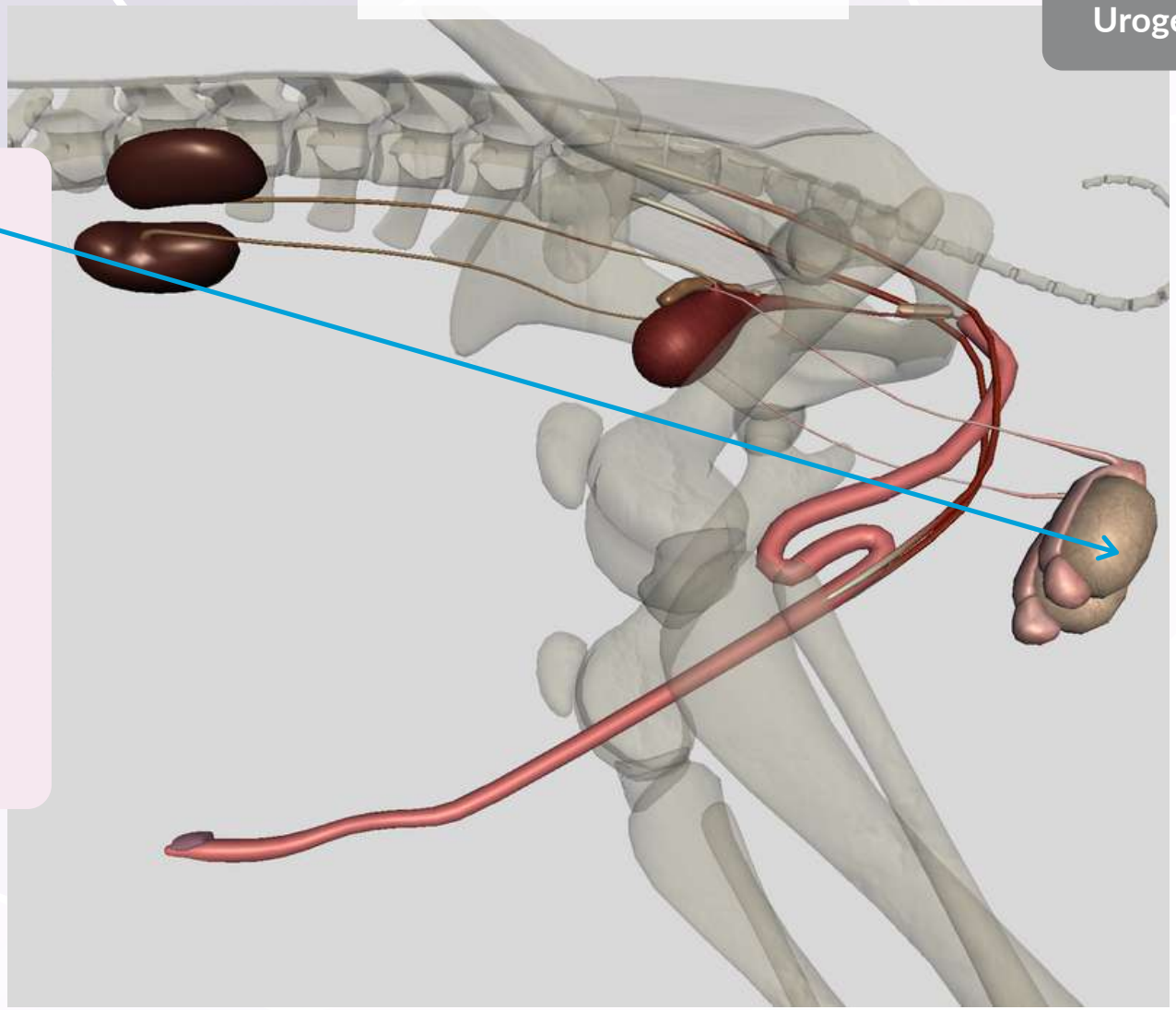


Testes

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.

Ovaries

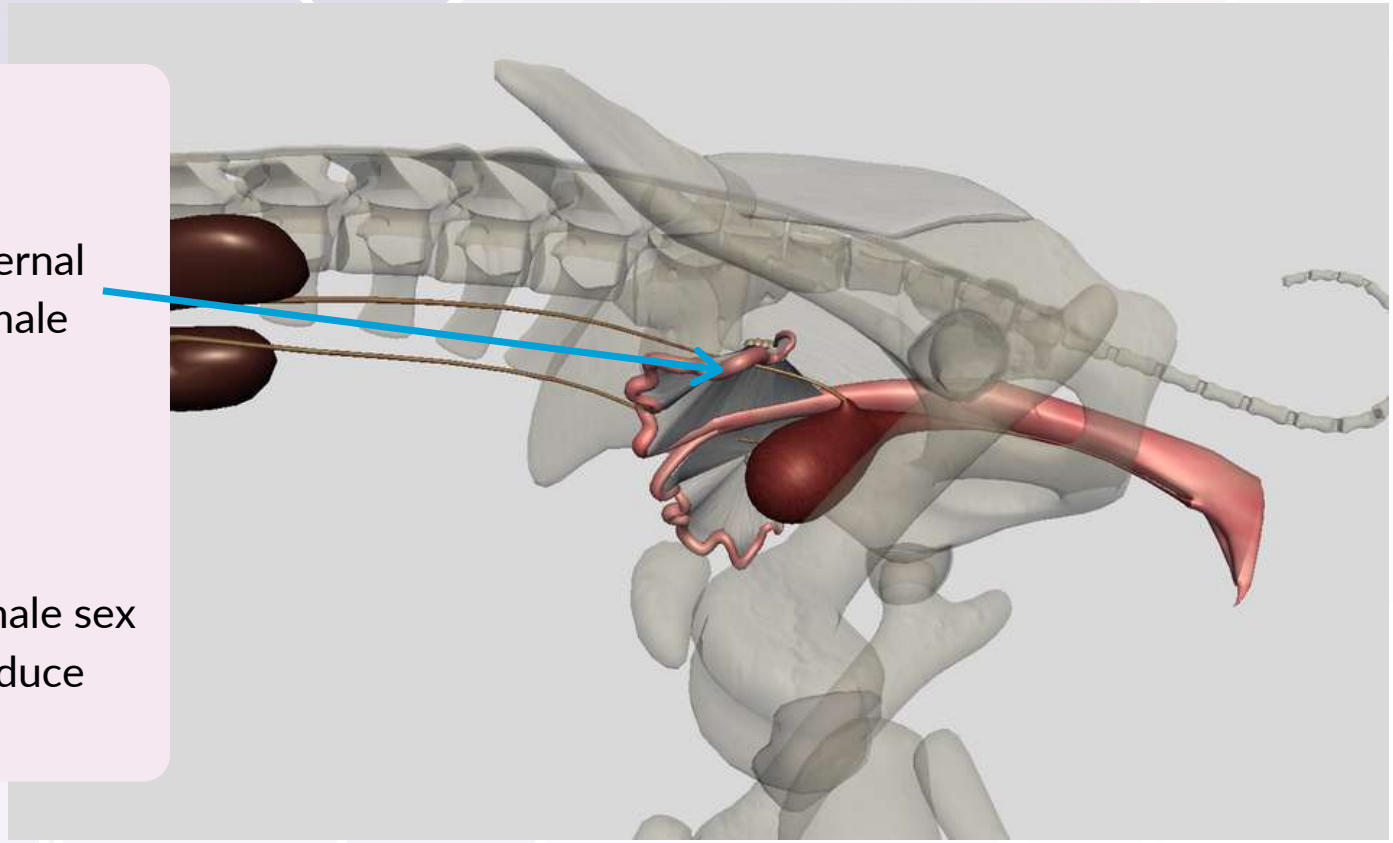
Turn off all other body systems and focus on these

- Skeleton
- Urogenital

Ovaries

Location: in the internal pelvic region of female pigs

Function: produce **estrogen** and **progesterone** - female sex hormones, and produce eggs.



Pituitary and Pineal Gland

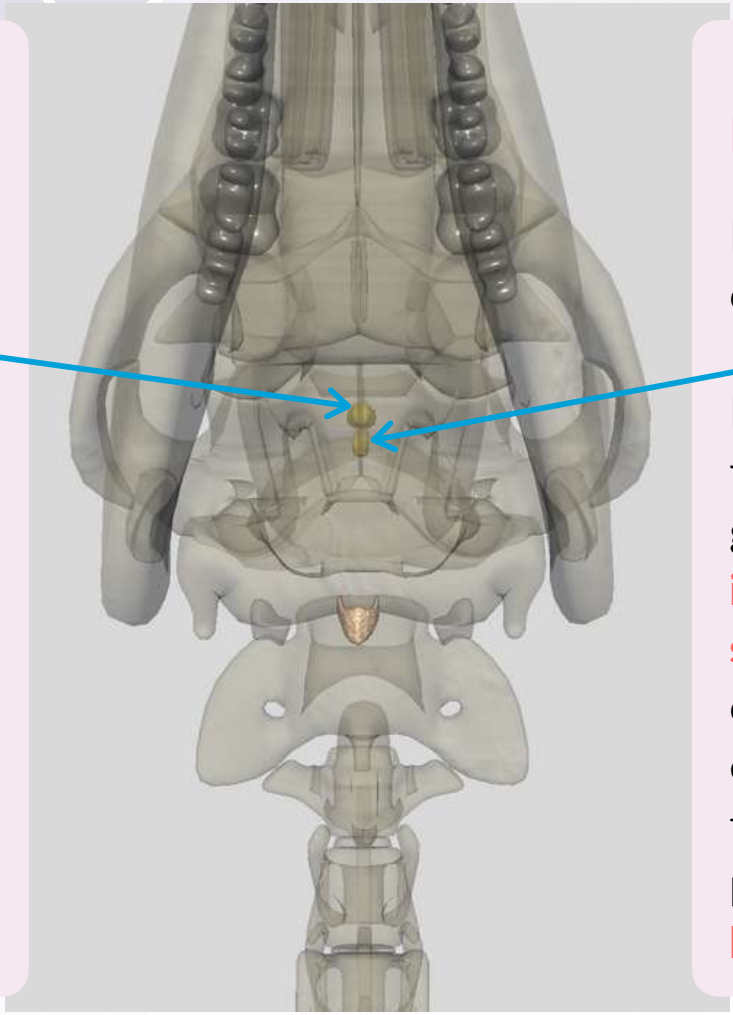
Turn off all other body systems and focus on these

- Skeleton
- Endocrine

Pituitary (hypohysis)

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.

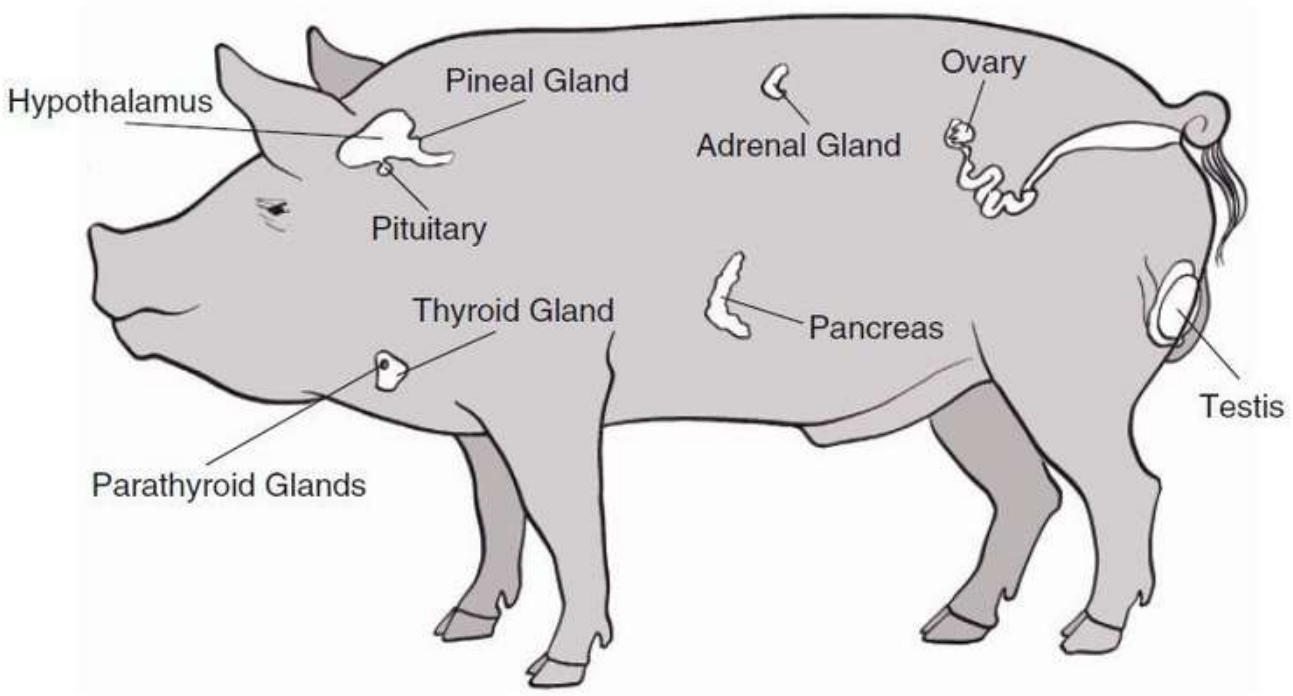


Pineal Gland

Location: deep in the centre 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 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.

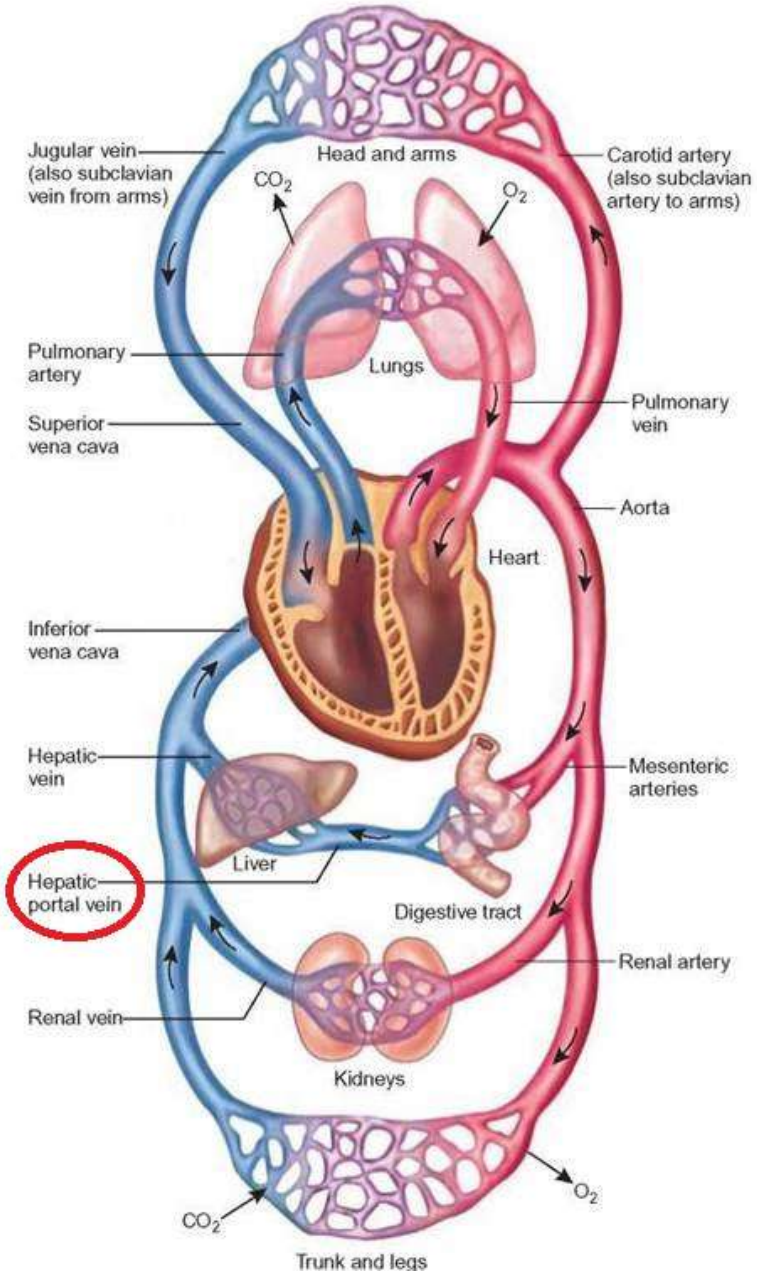
4. How do hormones interact with other body systems?

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

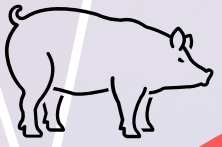
5. How do the nervous and musculoskeletal systems interact with each other?

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



Identify Some Key Similarities and Differences Between Pigs and Humans



PIG

HUMAN

Thank you for choosing these materials to support your anatomy adventures!

These Humane Science Education materials were developed by Elisabeth Ormandy for the Canadian Society for Humane Science (2015-2021) working to achieve better science without animals. By choosing these unit plans, you have joined a growing family of Humane Science Educators!

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