Rat Anatomy Student Workbook

(accompanies 3D Rat Anatomy app by Biosphera)

Contents

Learning Objectives

- Explain how key **anatomical features** help rats in their natural environments
- Describe the major **body systems** of rats and their major organs
- Explain the function of each major **organ**
- Explain how the major body systems in rats **work together** to create whole functioning organisms
- Identify key **similarities and differences** between rats and humans

Introduction to the Rat

In this lab, we will be taking a look at several body systems in the rat. Rats are **mammals**, just like humans. Keep this in mind as you explore the various organs that make up rats bodies!

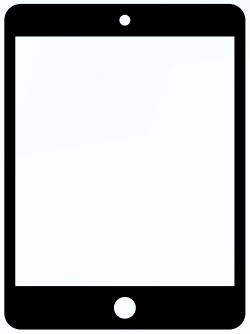
The body systems we will explore are:

Digestive
Musculoskeletal
Respiratory
Circulatory
Urinary
Endocrine
Nervous & Sensory

Getting To Know 3D Rat Anatomy

By: Biosphera

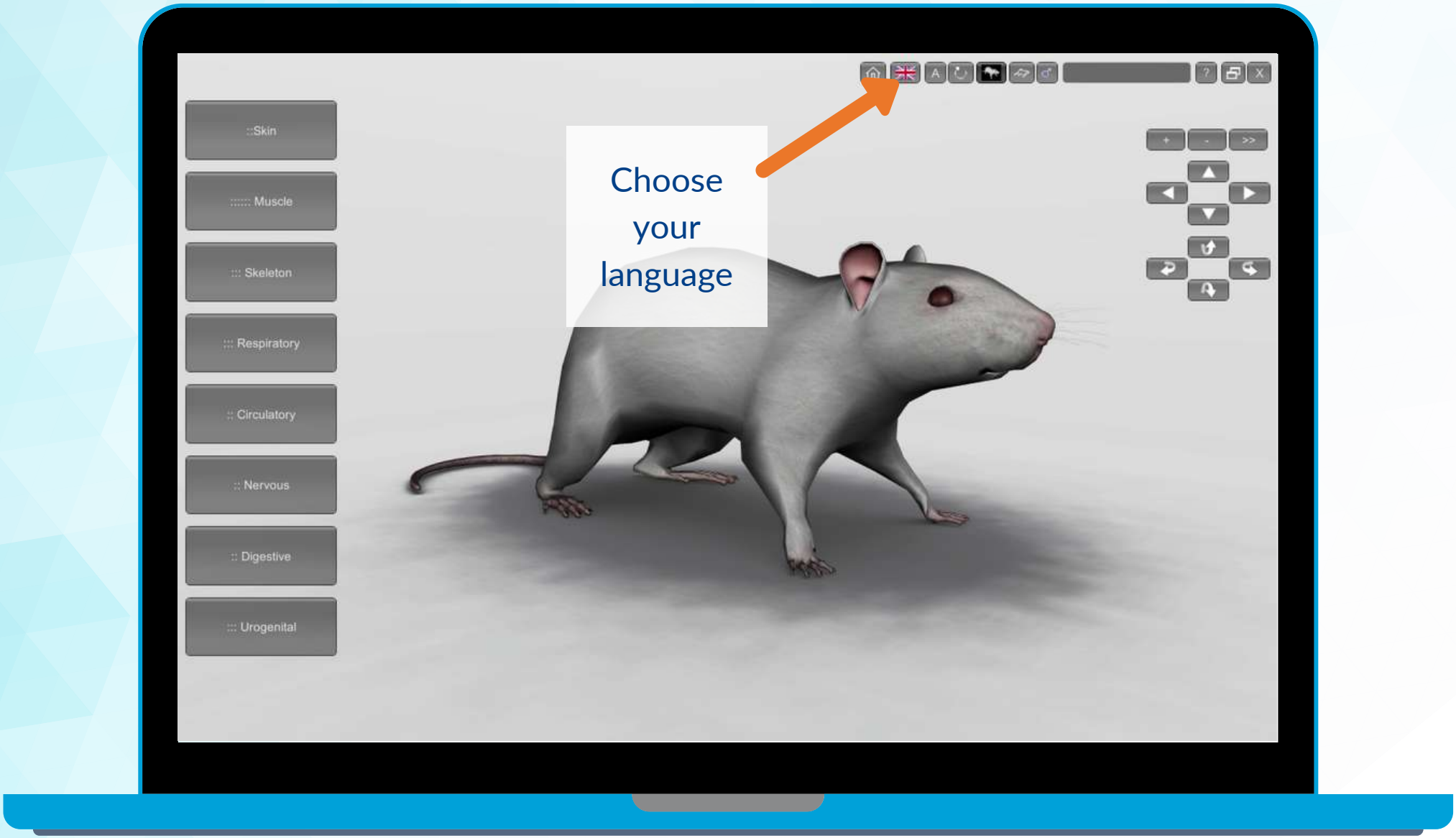
The app is available for iPads, Android tablets and desktop: www.biosphera.com

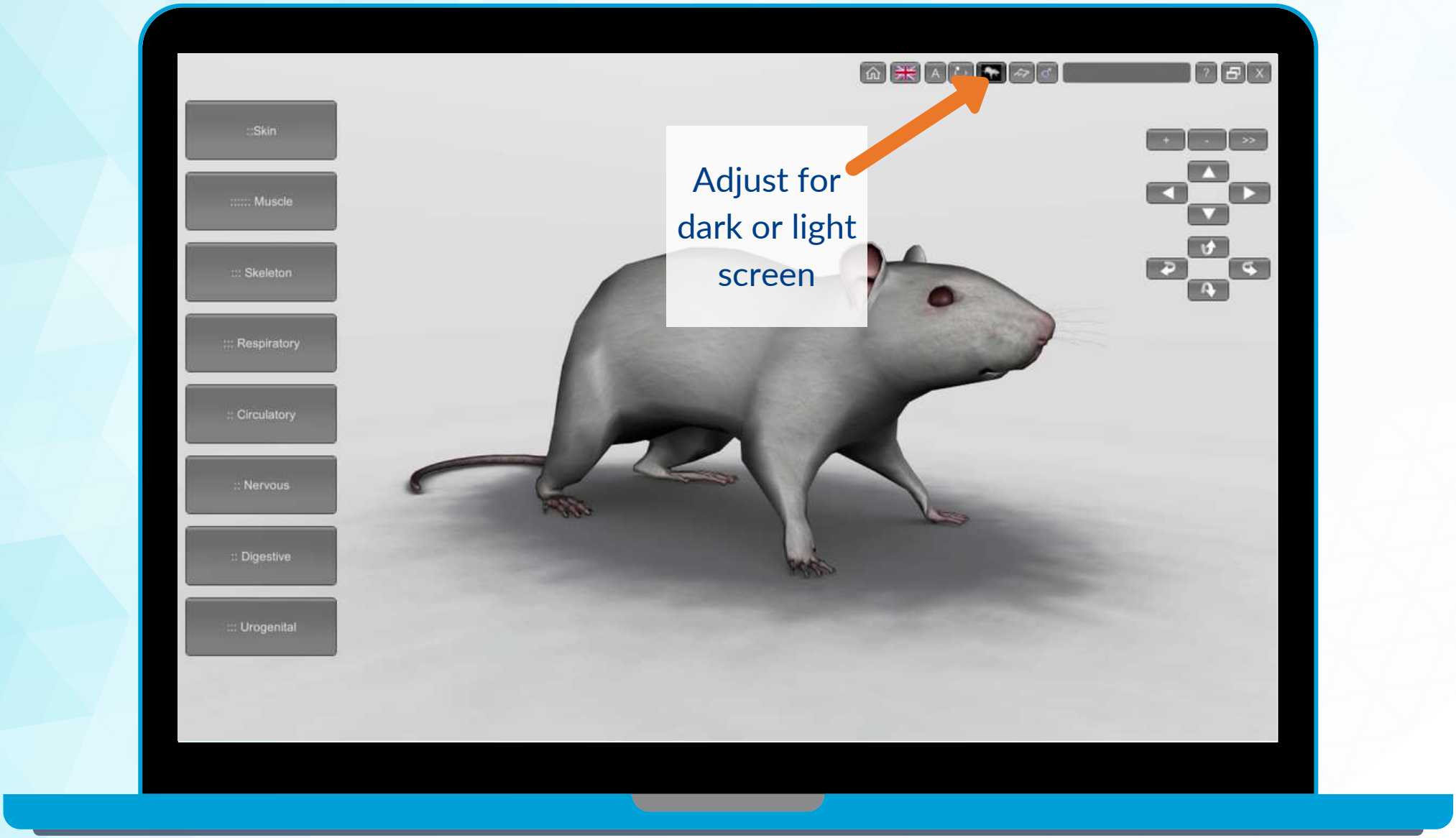


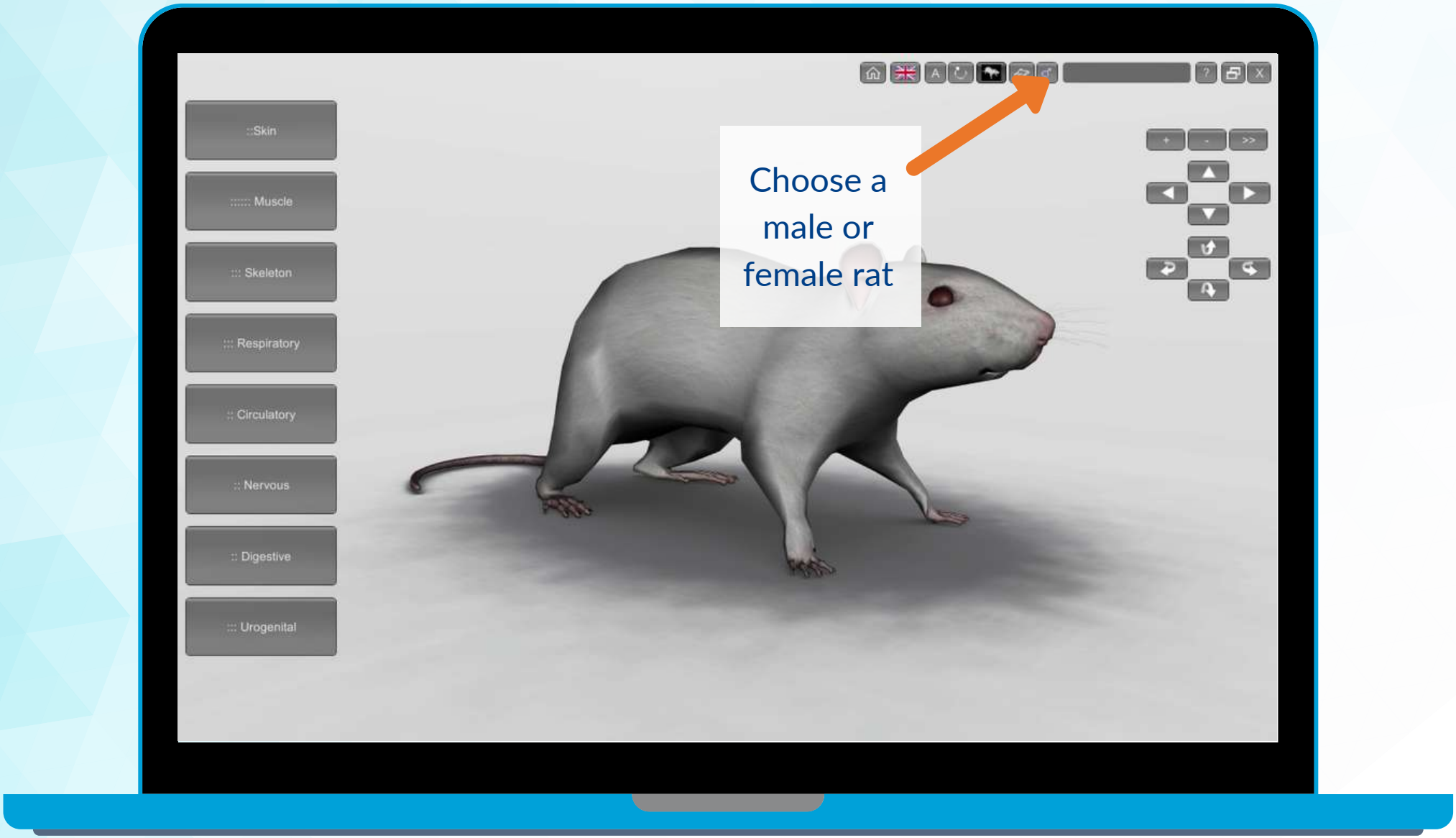
Lets get comfortable with the app!

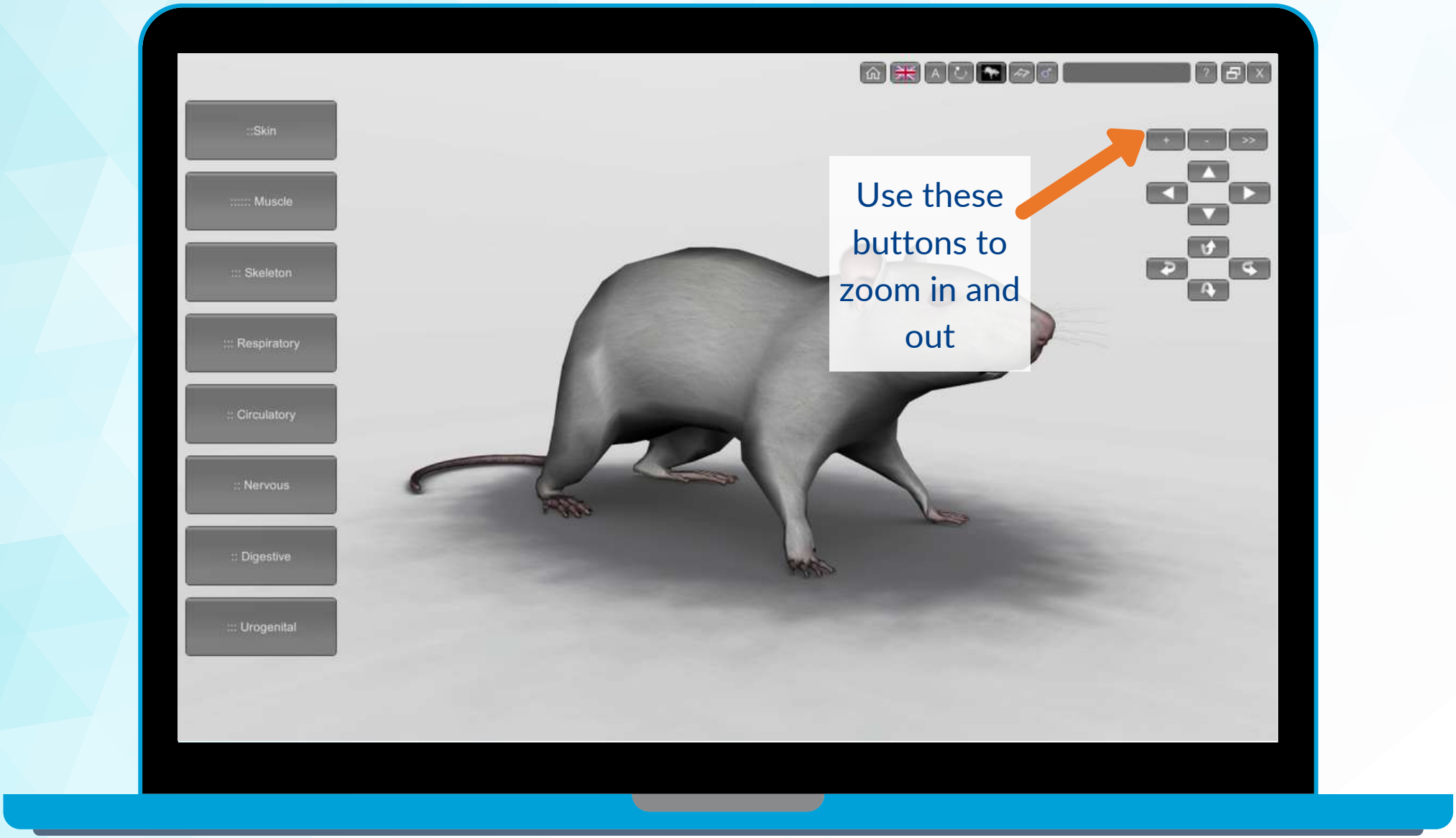
Take a few minutes to explore the app.

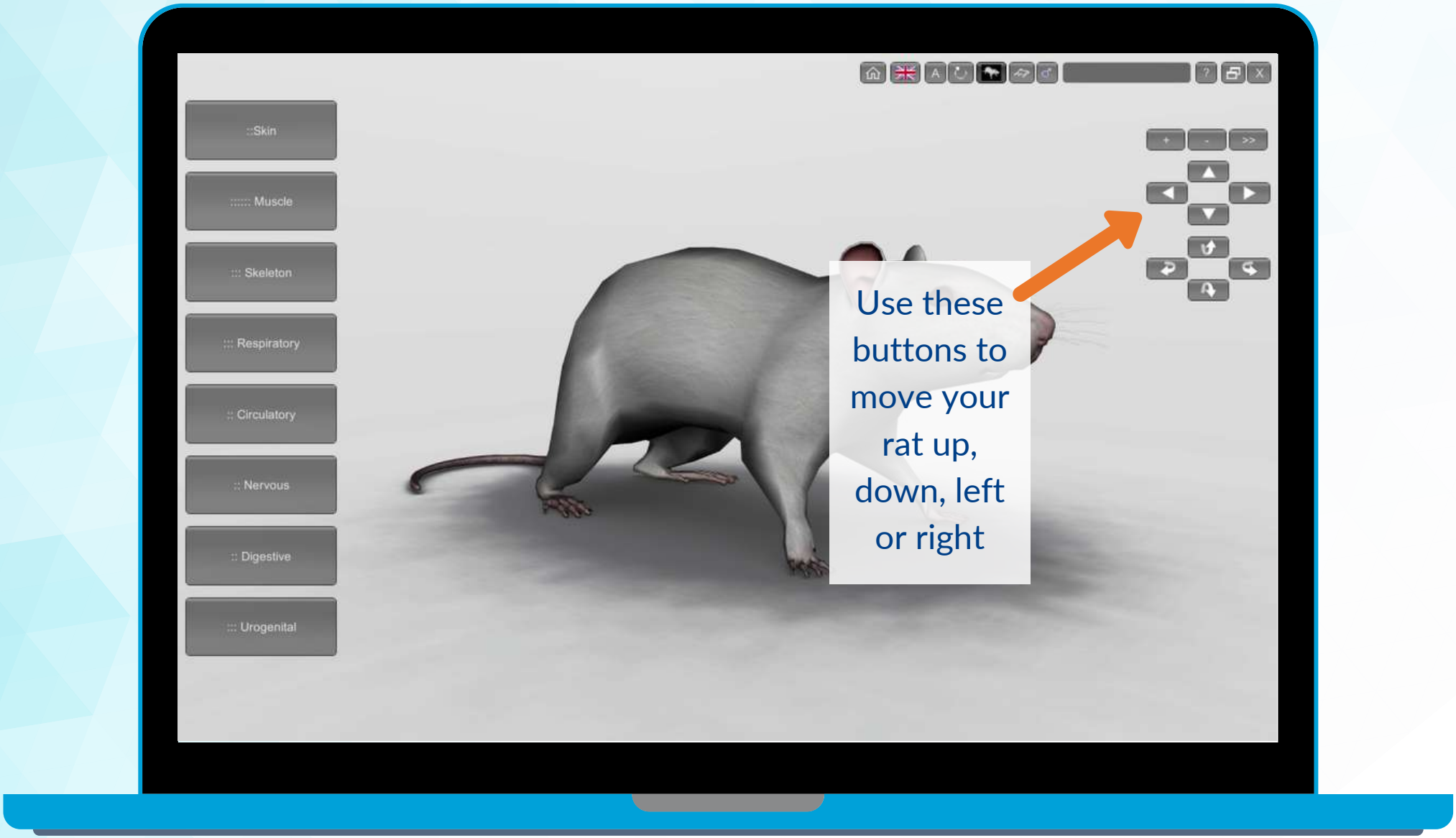
Press buttons, move the model around, and touch/hold the organs... See what happens!

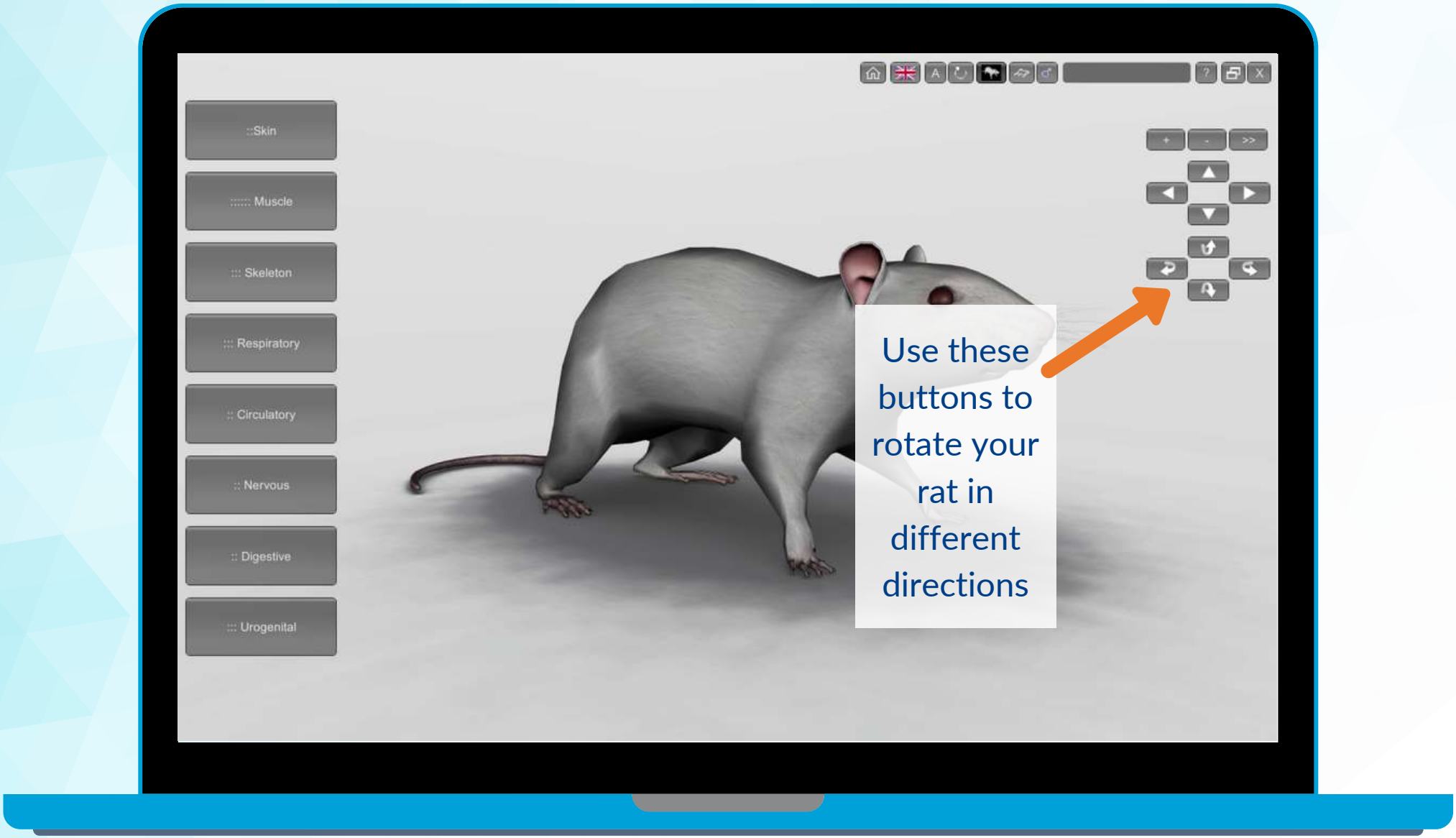


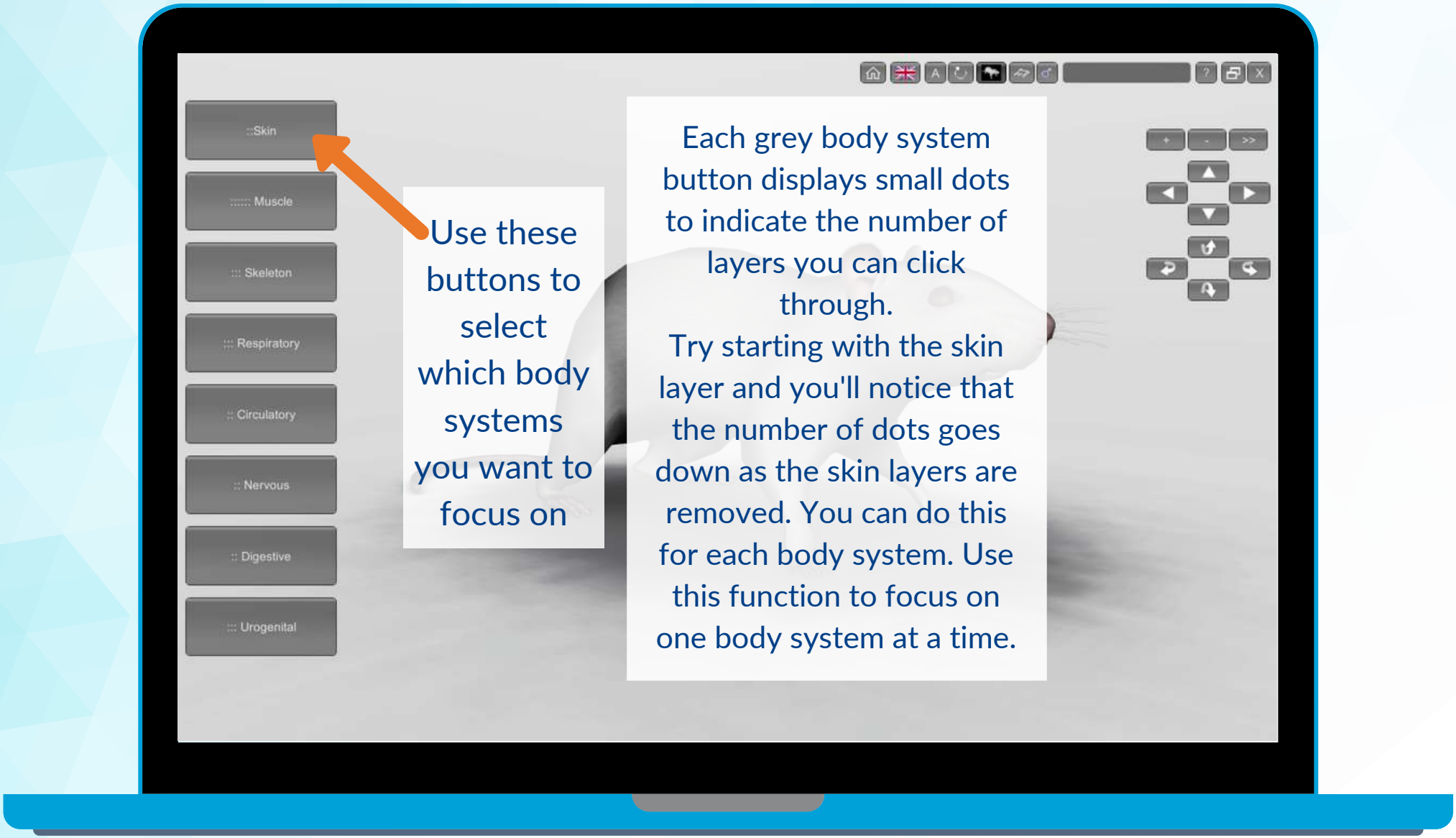












Here's what your rat should look like when you click the SKIN button ONCE

Notice how the SKIN button now only has one set of dots, instead of two

Some Terms To Know

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

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.

Digestive System

Digestive System - External Anatomy

: Skeleton

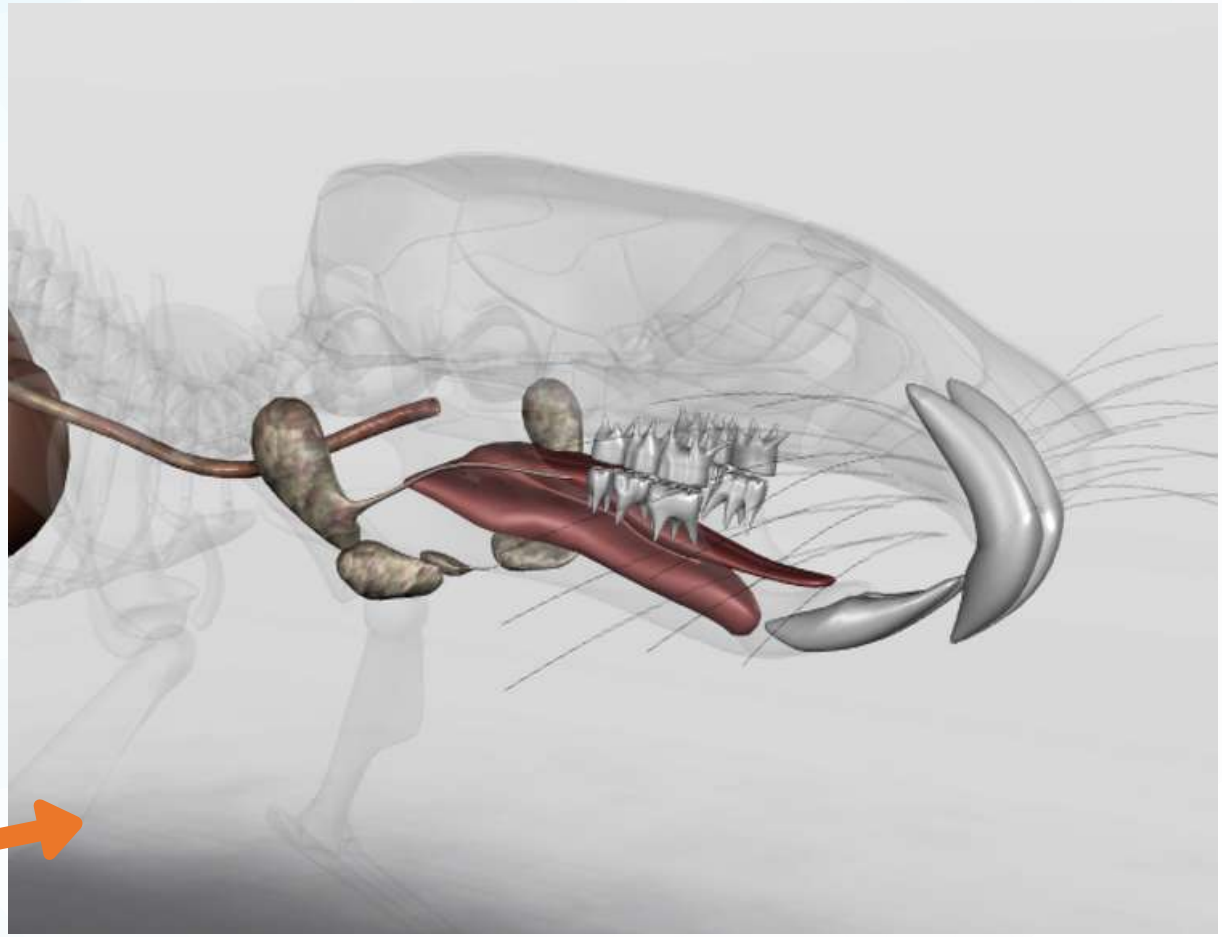
:: Digestive

Turn off all other body systems and focus on these

Rotate your rat 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
- 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 rat?

Carnivore

Omnivore

Herbivore

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

: Skeleton

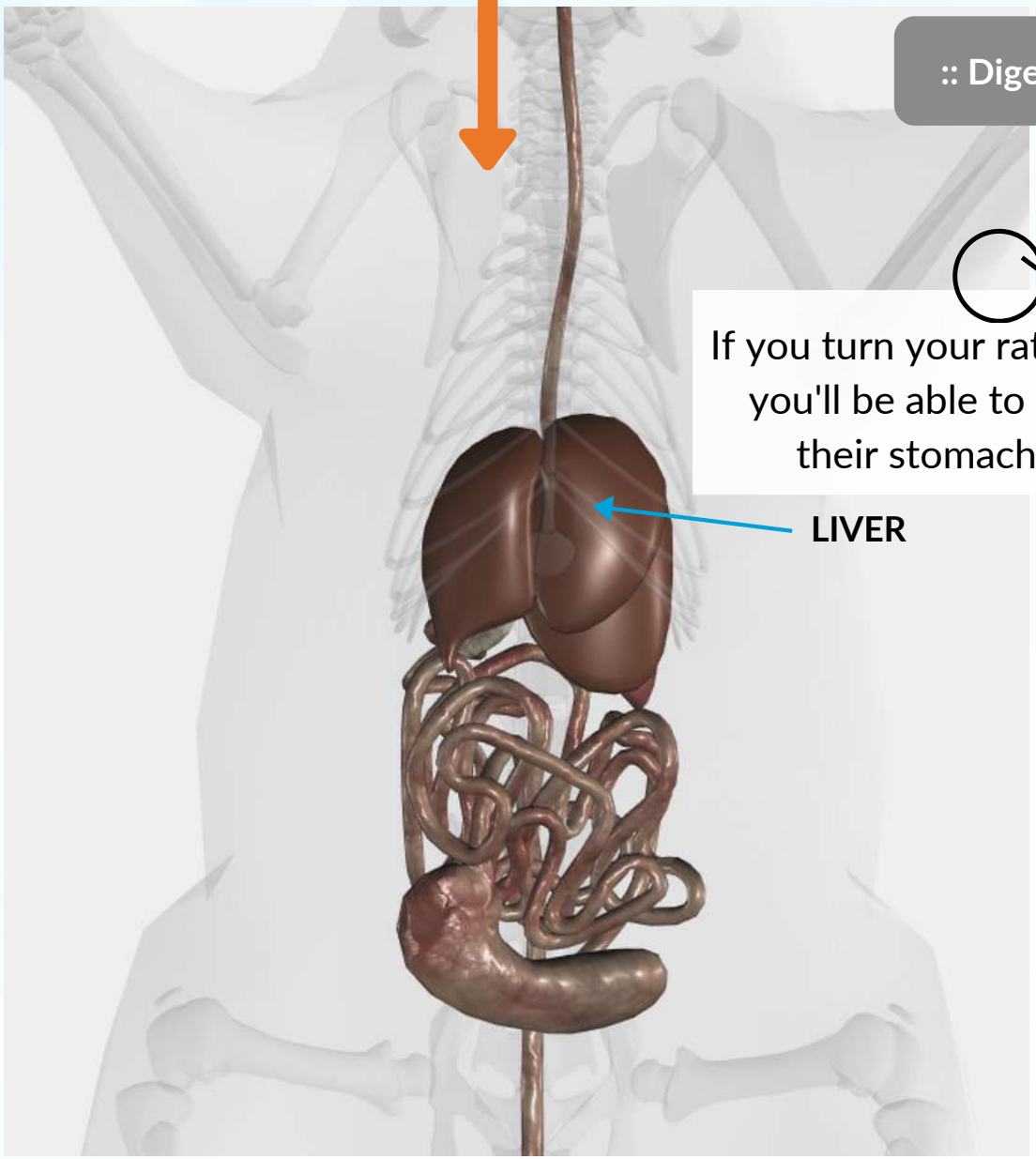
:: Digestive

Rotate your rat so you are looking at the **ventral** view (put your rat 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.

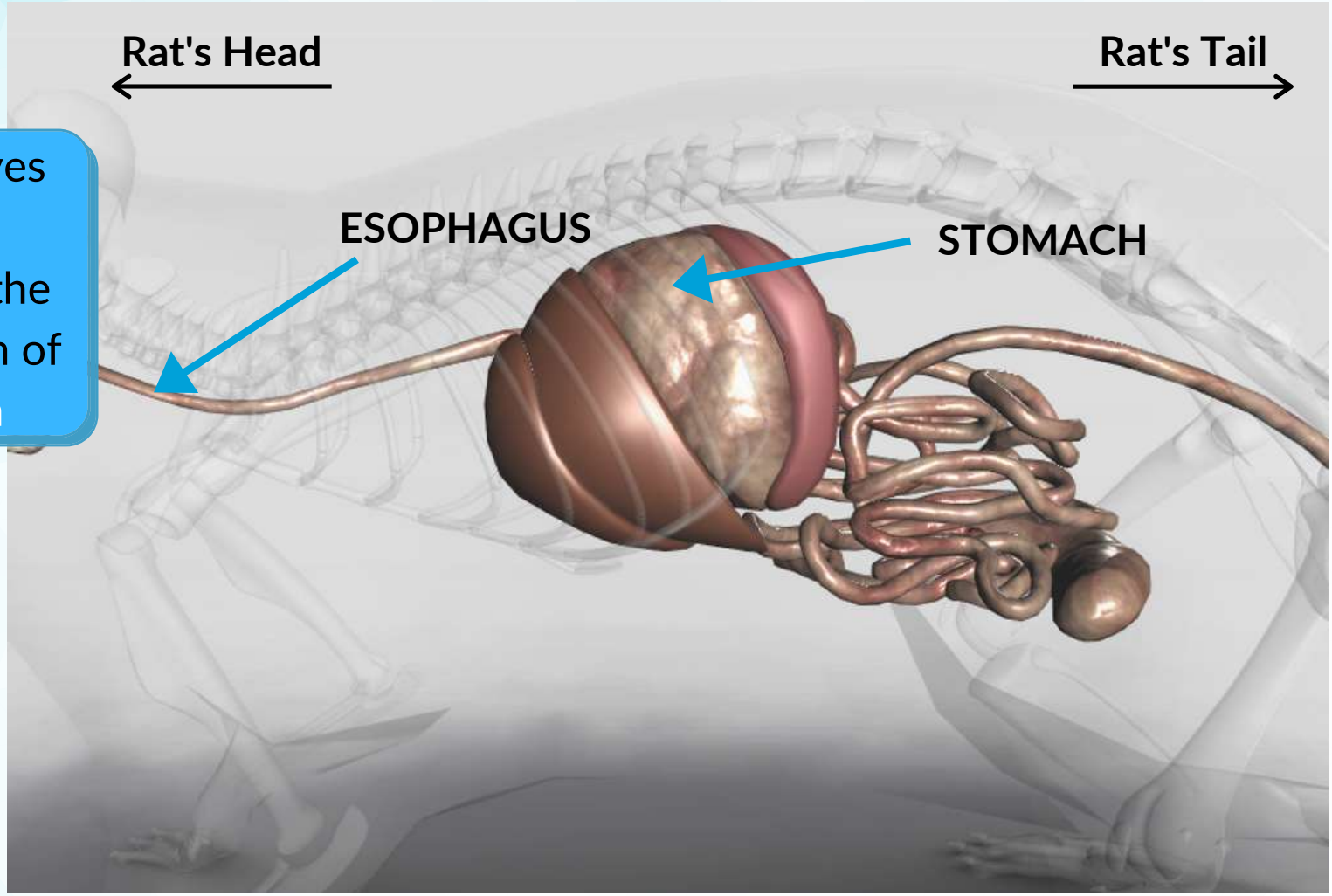
Food travels down esophagus towards stomach



If you turn your rat over you'll be able to see their stomach!

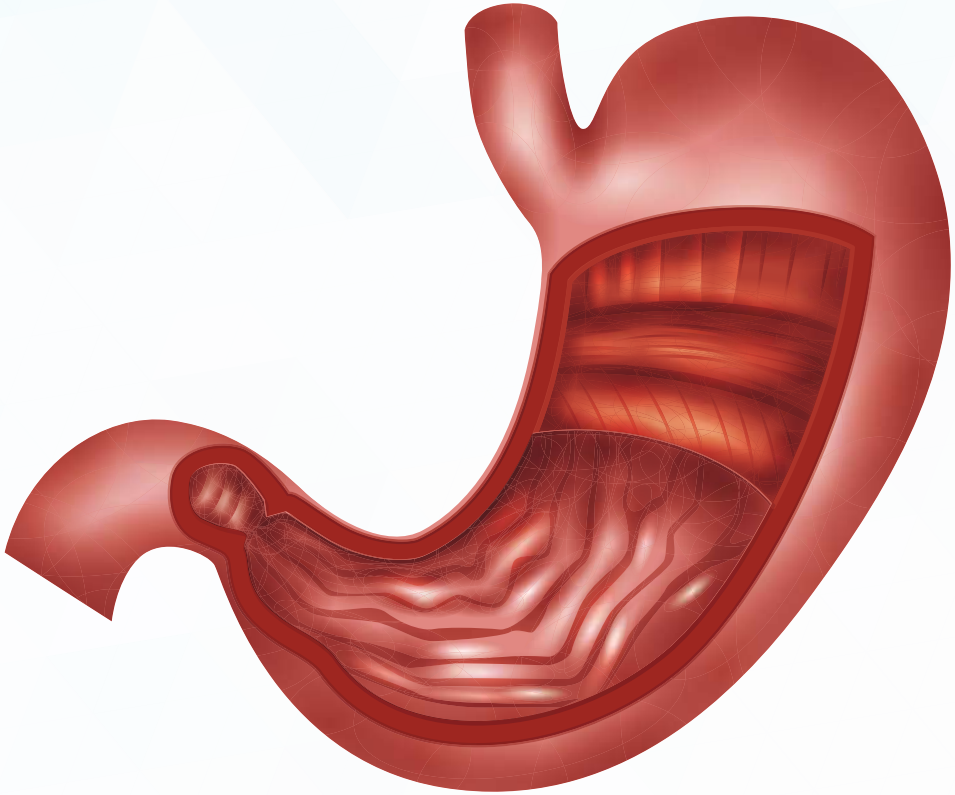
LIVER

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



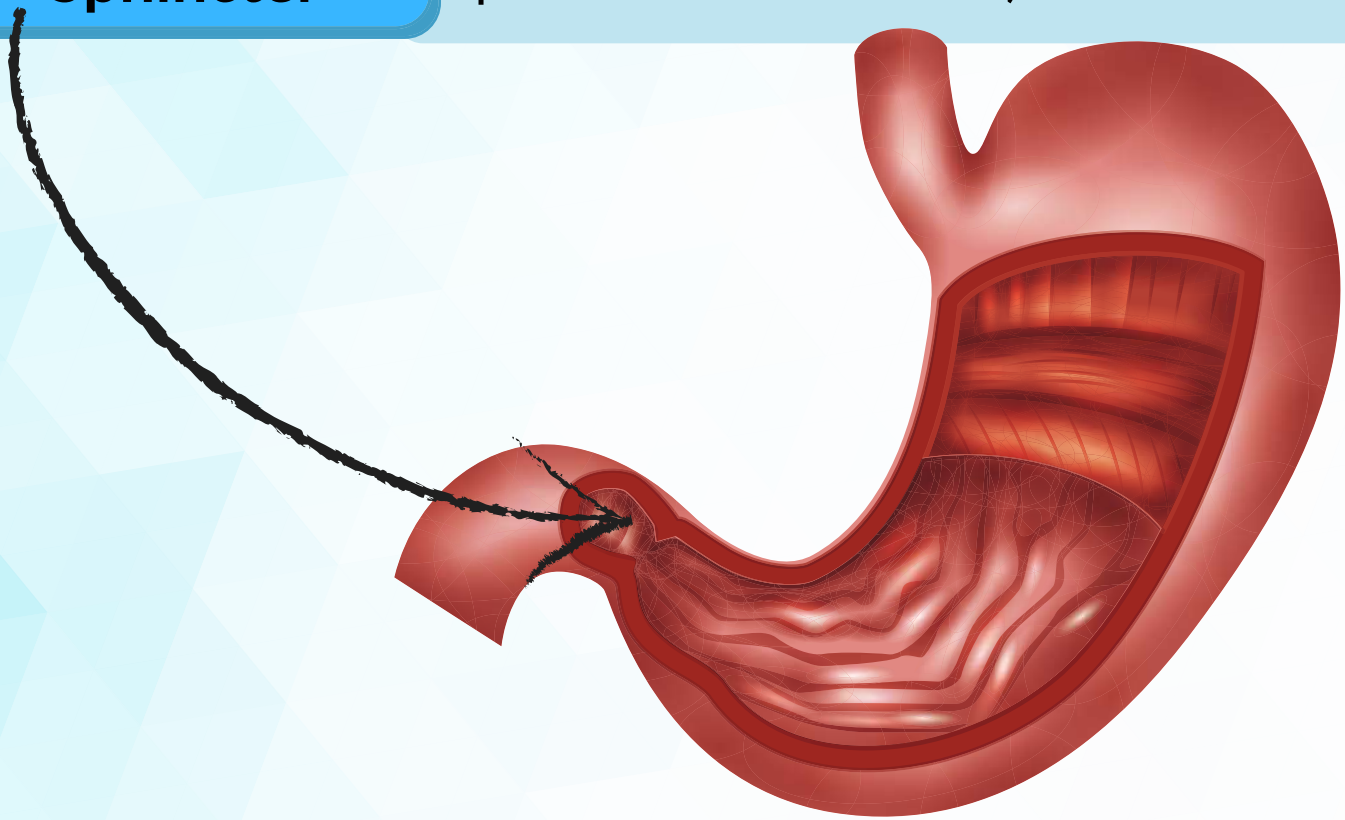
Stomach

- 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

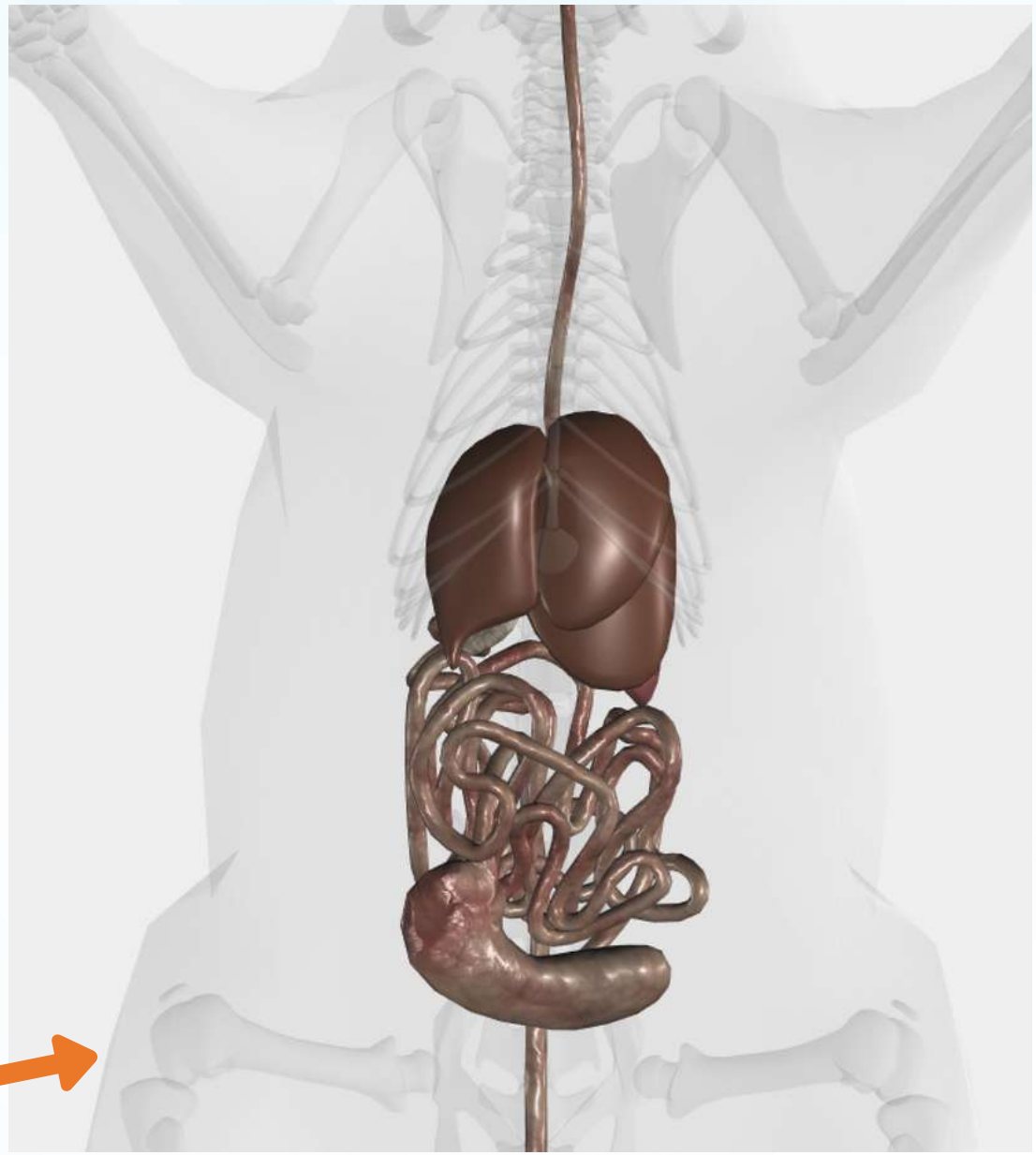
Valve between the stomach and duodenum (first part of small intestine)



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

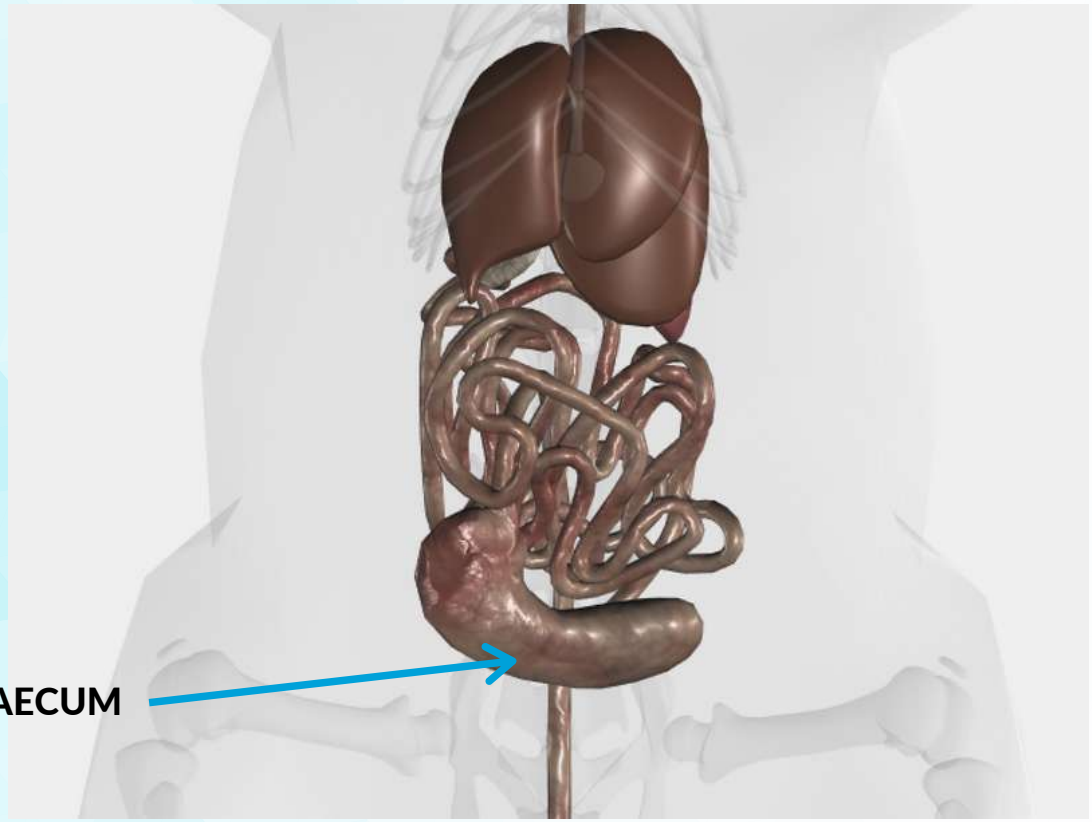
Find the **small intestine** on your rat

Can you label it 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

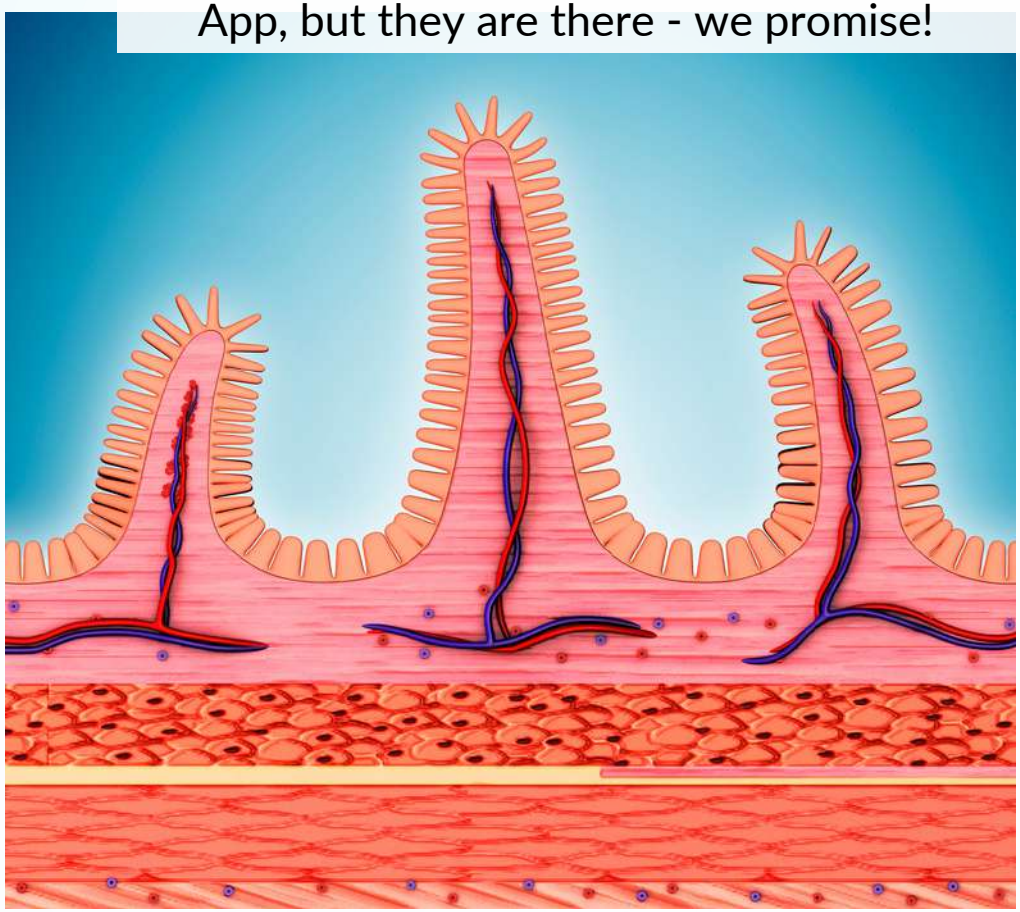
Intestinal Villi

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

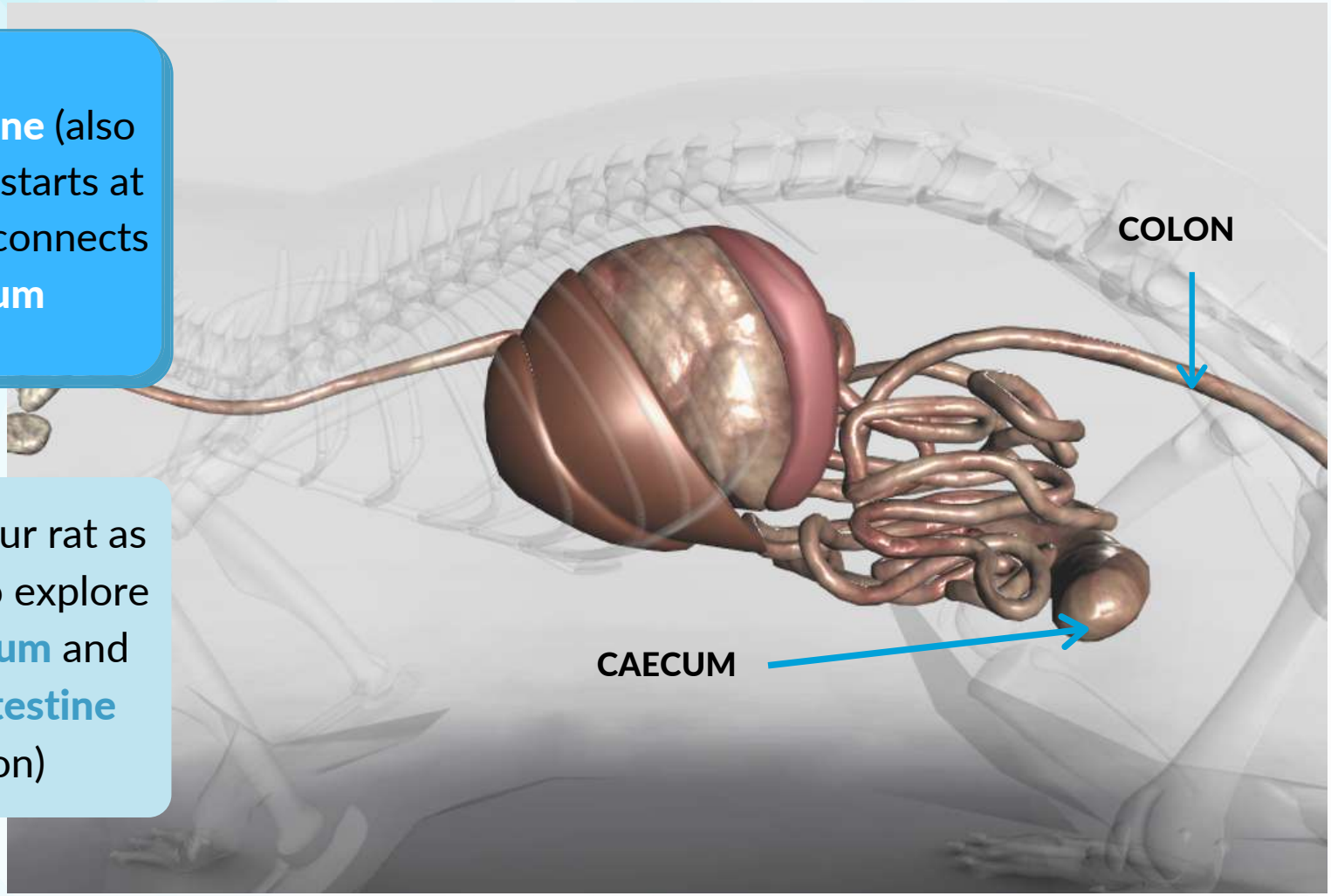
You won't see villi on the 3D Rat Anatomy App, but they are there - we promise!



Large Intestine

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

Rotate your rat 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.

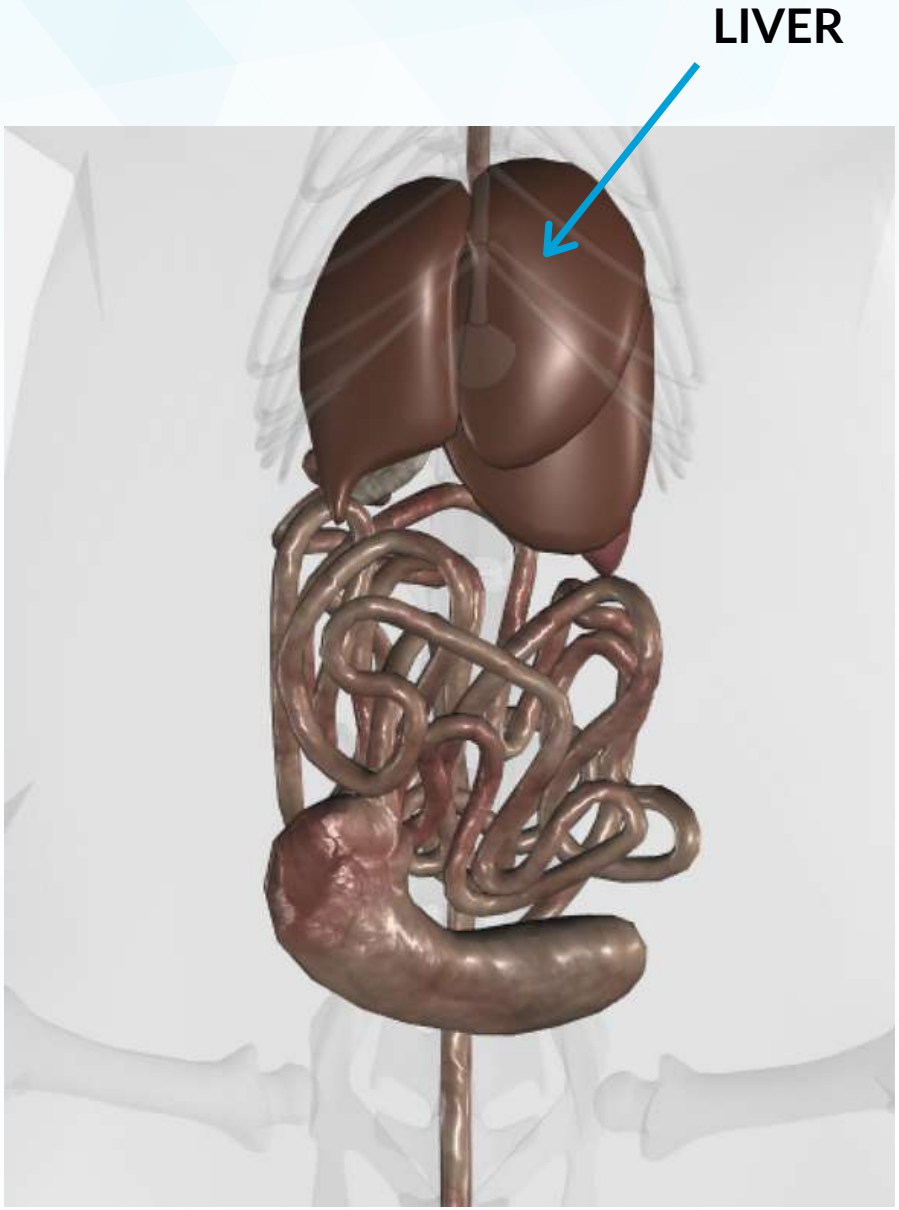
Why do you think some carnivores have a very small or sometimes non-existent caecum?

Some animals do not consume plant matter, so the caecum is unnecessary.

The caecum of herbivores is much larger than the caecum of omnivores. Herbivores consume more cellulose and water, making a larger caecum necessary for effective digestion.

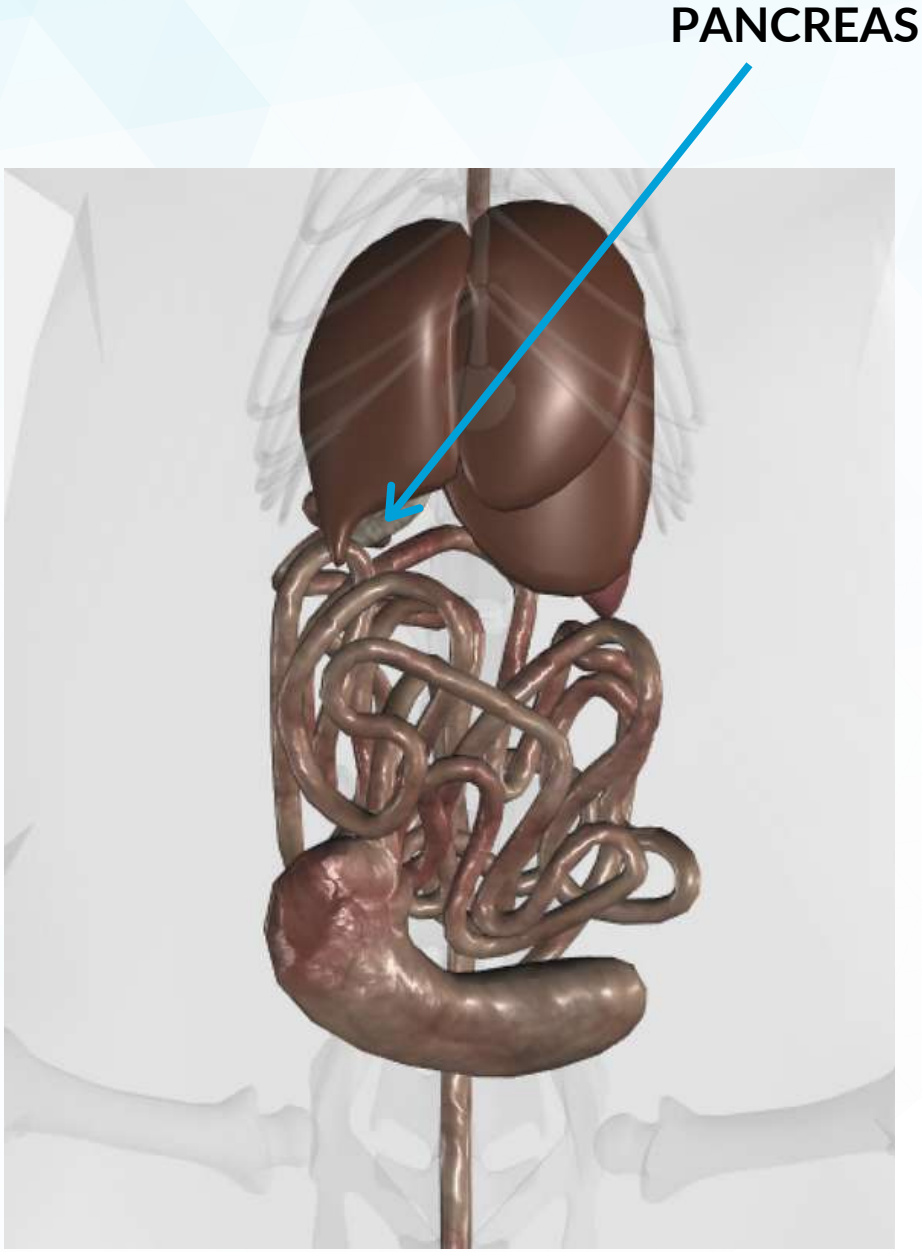
Liver

- 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

- Location: dorsal to **stomach**, wrapped in the duodenum
- Structure: flattened gland found in between stomach and small intestine
- Function: produces 2 major secretions
- 1) **digestive enzymes:** responsible for breakdown of fats, carbs, and proteins
- 2) **insulin:** a hormone which allows cells to absorb glucose



Common Bile Duct

- Location: connects **liver** to upper portion of **small intestine**, also known as the **duodenum**
- Structure: small, tube-like
- Function: **carries bile** from the liver into the duodenum
  - Bile is needed to break down fats

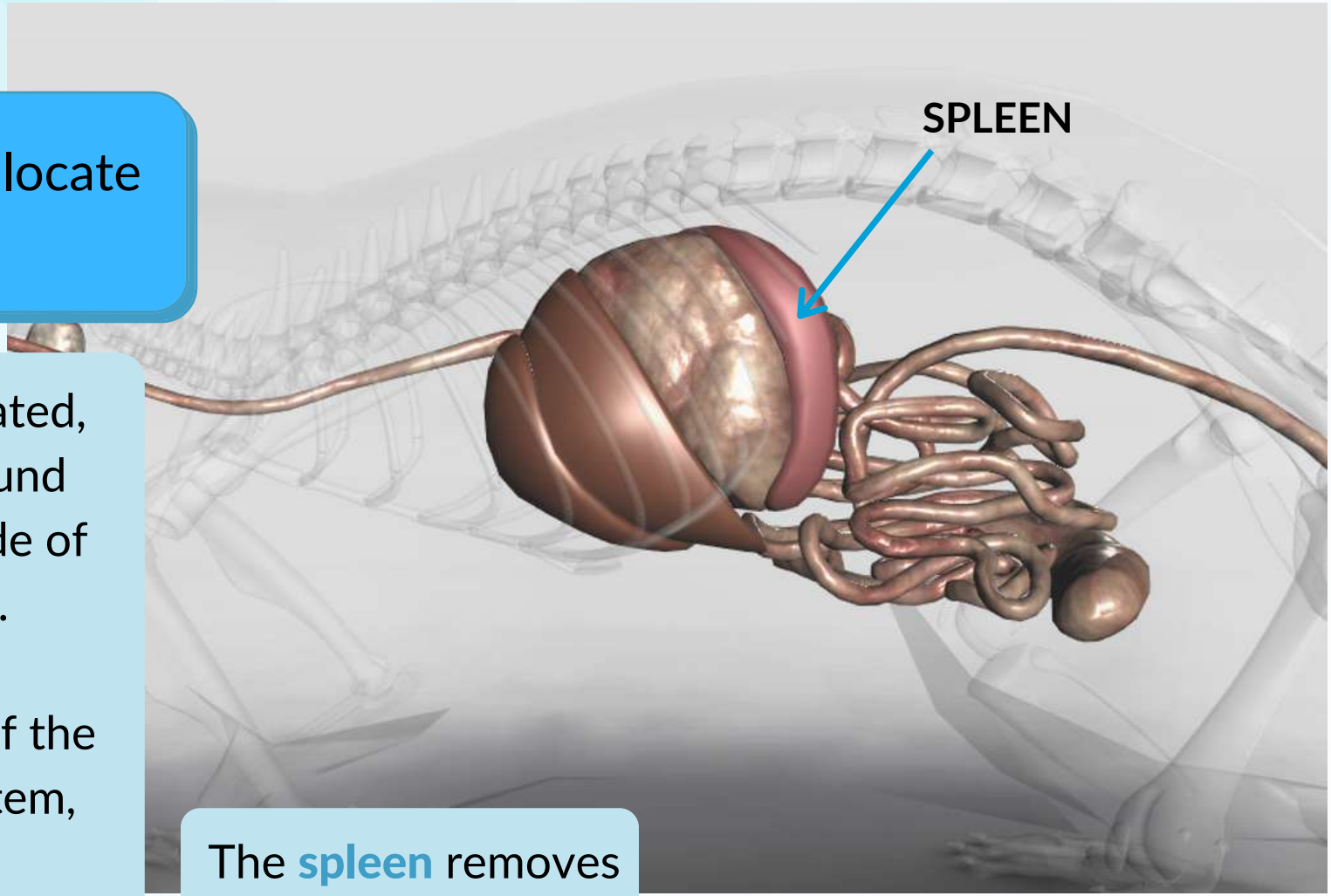
Humans have a gall bladder, which concentrates bile. What are some reasons you think this structure is absent in rats?

Many hypotheses, one of the more popular: herbivores and other animals who eat low concentrations of fat, or forage continuously (ex. rats), don't need one

Their liver might be able to concentrate higher levels of fats

Spleen

Finally, let us locate the **spleen**



It is an elongated, red, organ found on the left side of the rats body.

It's not part of the digestive system, however it is nestled in with the digestive organs.

The **spleen** removes old blood cells and break them down.

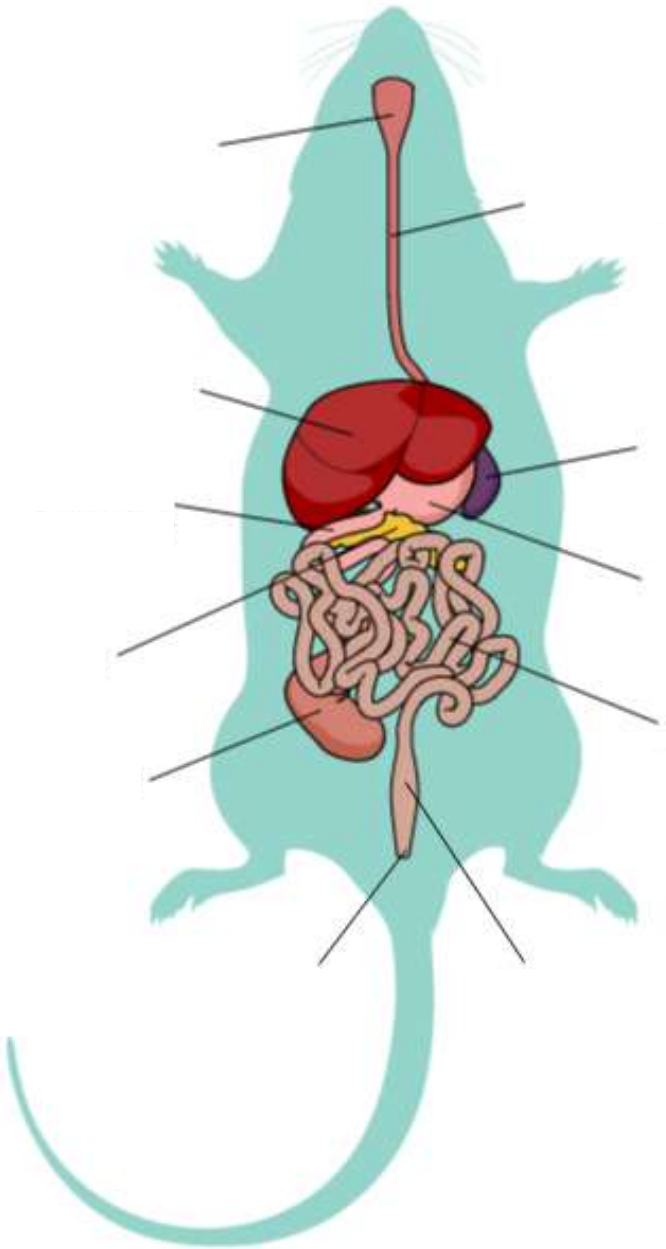
Review Break

- 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 rat takes a bite, to the moment it poops!

- Choose one person to explain it to the class.

QUIZ!

Label the rat digestive system diagram below.

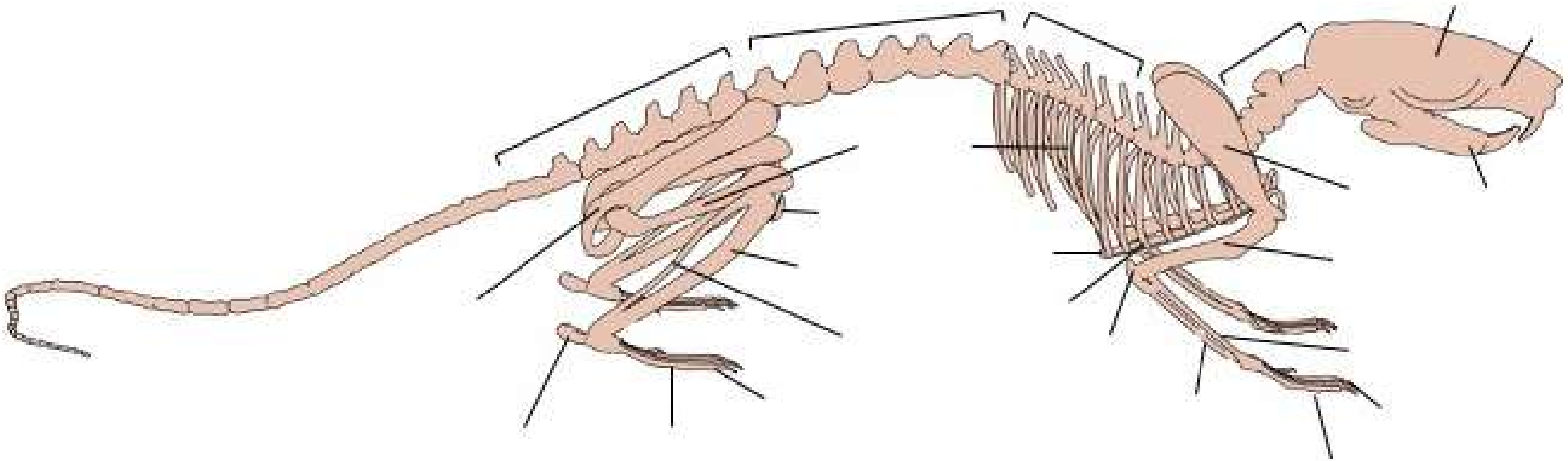


Musculoskeletal system

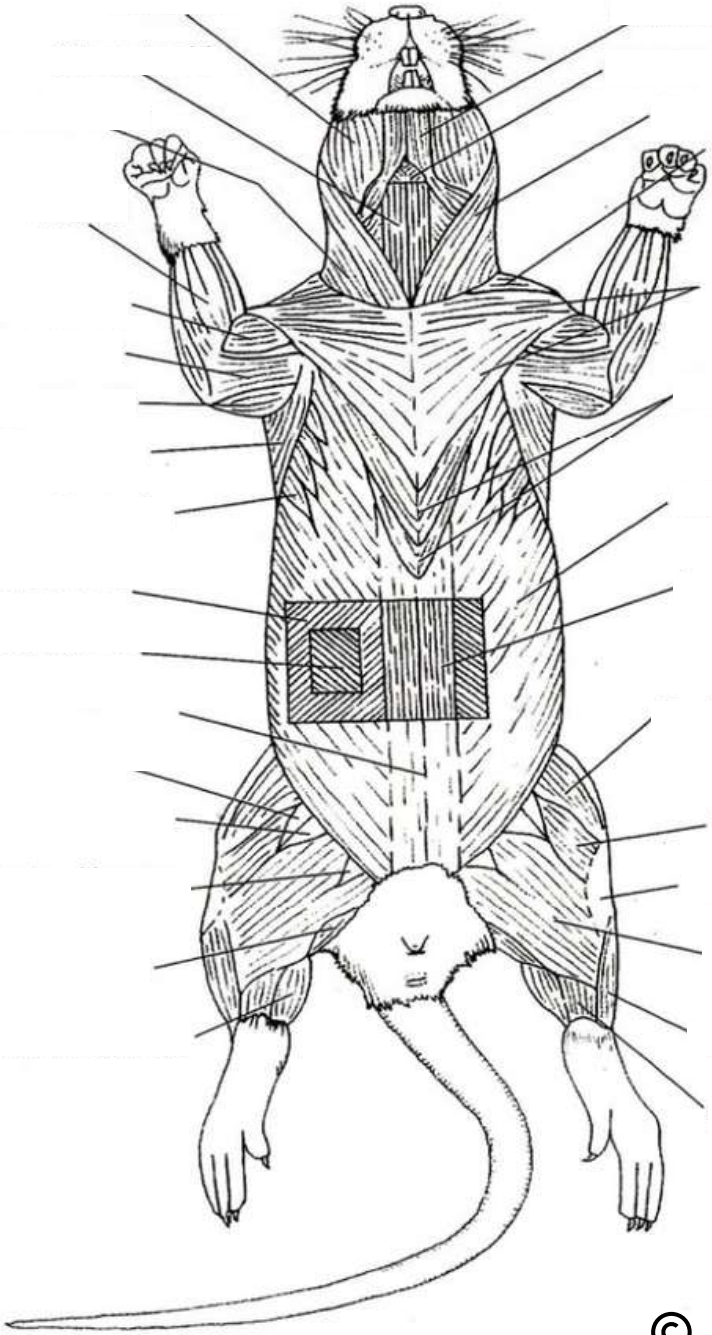
Bones

Turn off all other body systems and focus on the skeleton → :: Skeleton

Use your 3D Rat Anatomy app to label all the bones on this rat skeleton



Muscles



Turn off all other body systems and focus on the muscles

::::: Muscle

Use your 3D Rat Anatomy app to label the muscles on the diagram (hint: you might need to peel back muscle layers 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 rat.

Respiratory system

Lungs and Trachea

Turn off all other body systems and focus on these

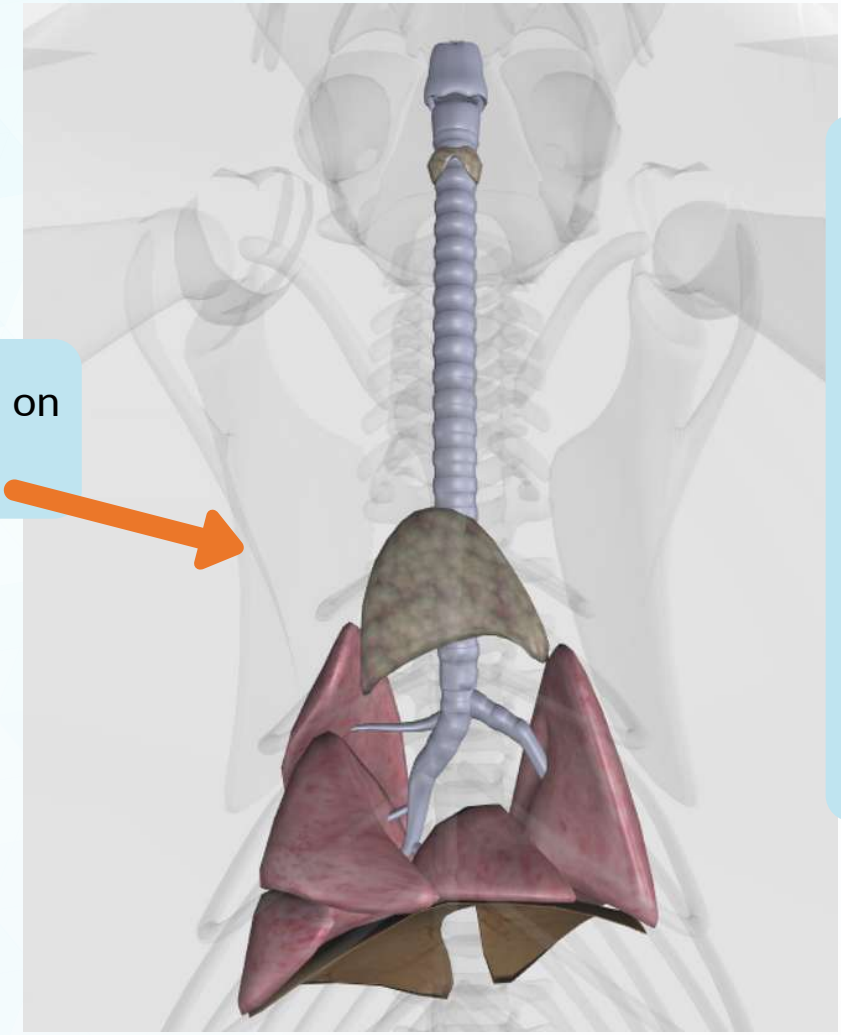
: Skeleton

:: Respiratory

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

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

Can you label them on the image?



Lungs

Location: chest cavity

Structure: large, spongy expandable organ

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

Do you notice a difference between each lung?

- The heart is located on the left side of the body
- 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 animal inhales

Trachea

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

Bronchial tube

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

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

Bronchioles

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

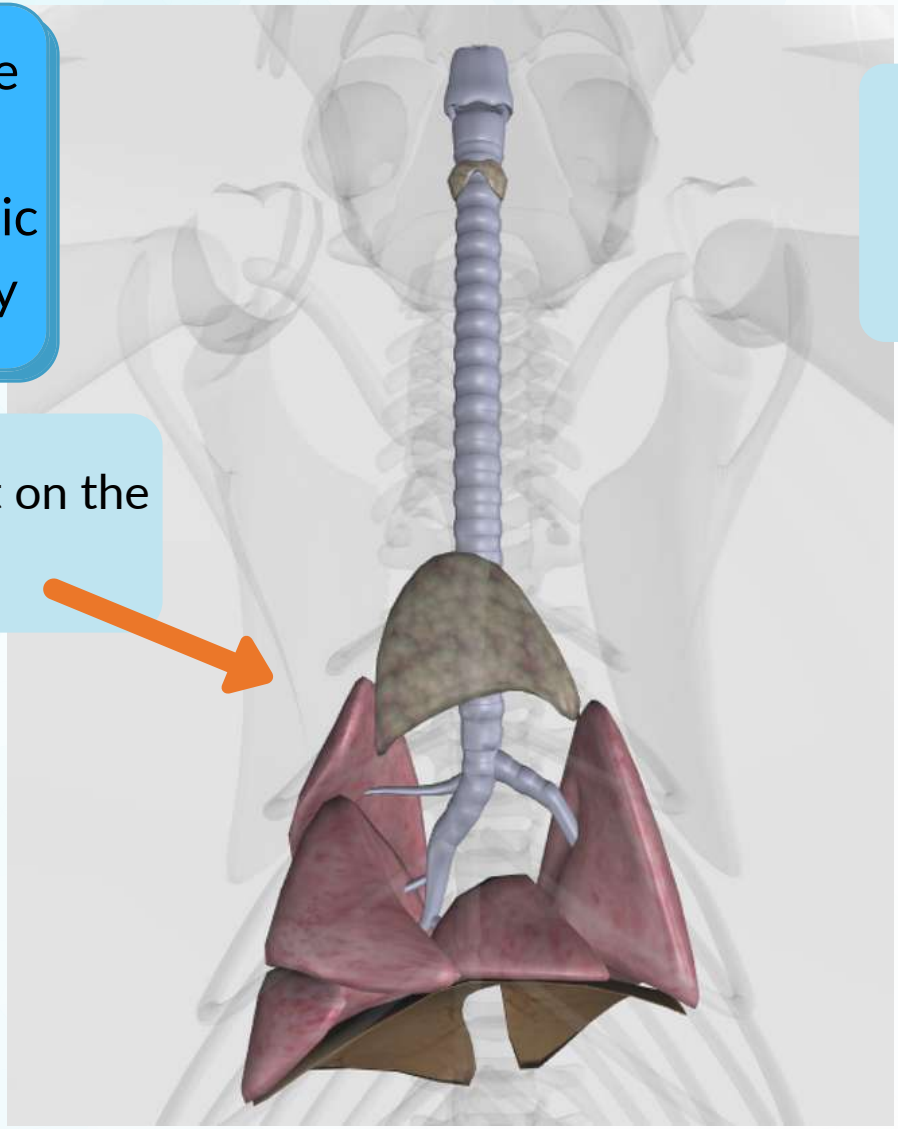
Alveoli

- 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?

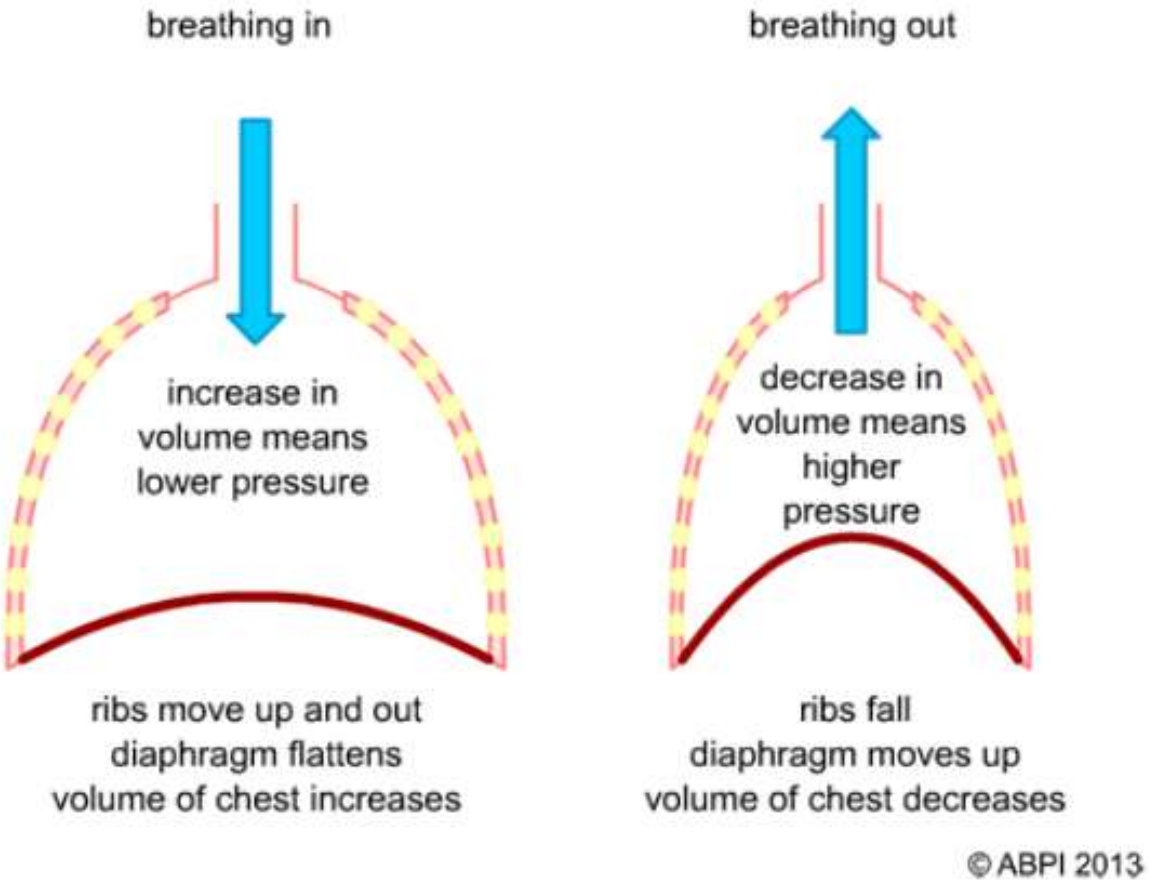


What would happen to the thoracic cavity if the diaphragm flattens?

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.

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

Review Break

- With your group, trace the path of air from the moment it is breathed in through the nose or mouth, to the moment it is exhaled.

- Choose one person to explain it to the class.

Circulatory System

Turn off all other body systems and focus on these

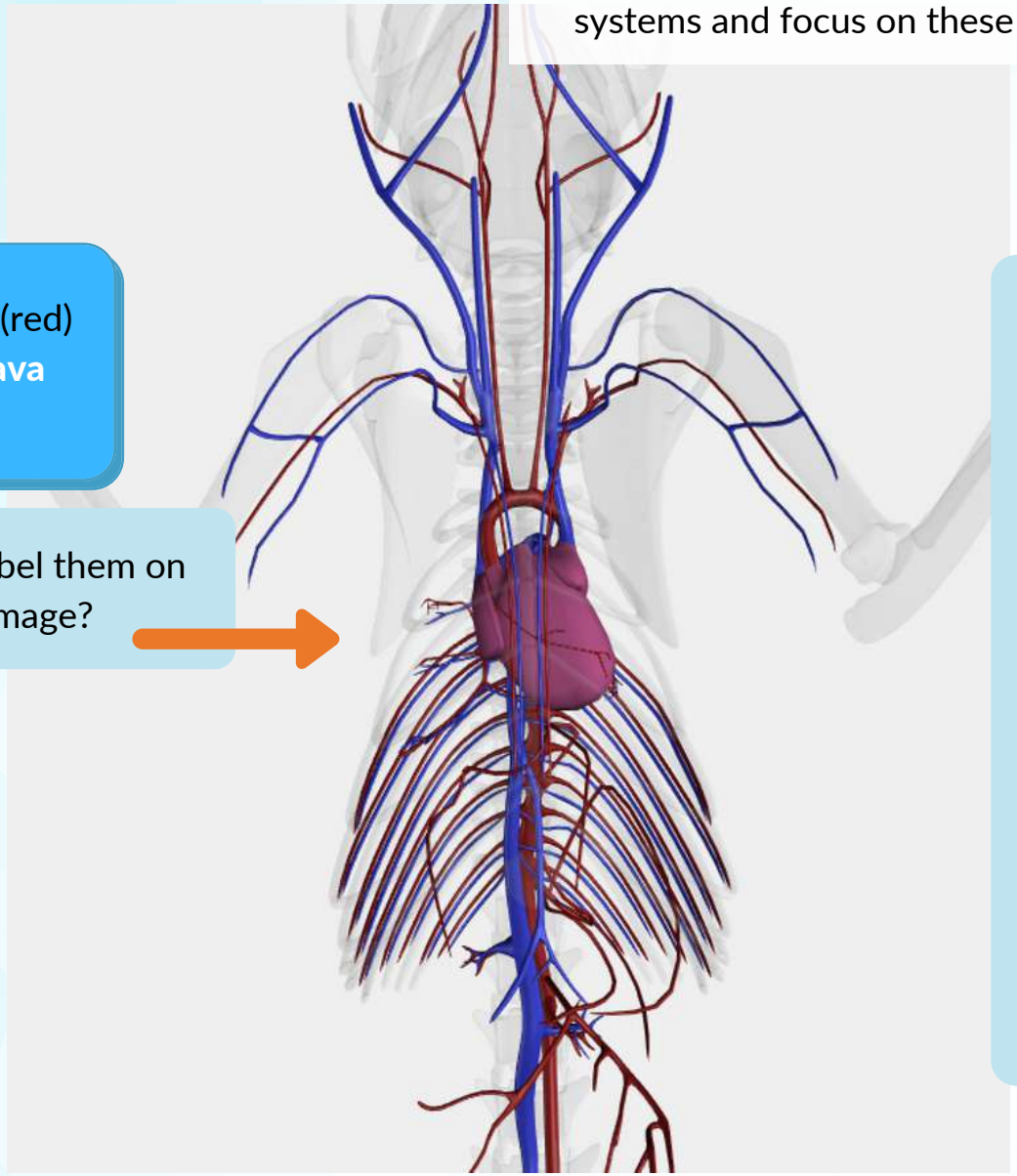
: Skeleton

:: Circulatory

Locate the rat'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)

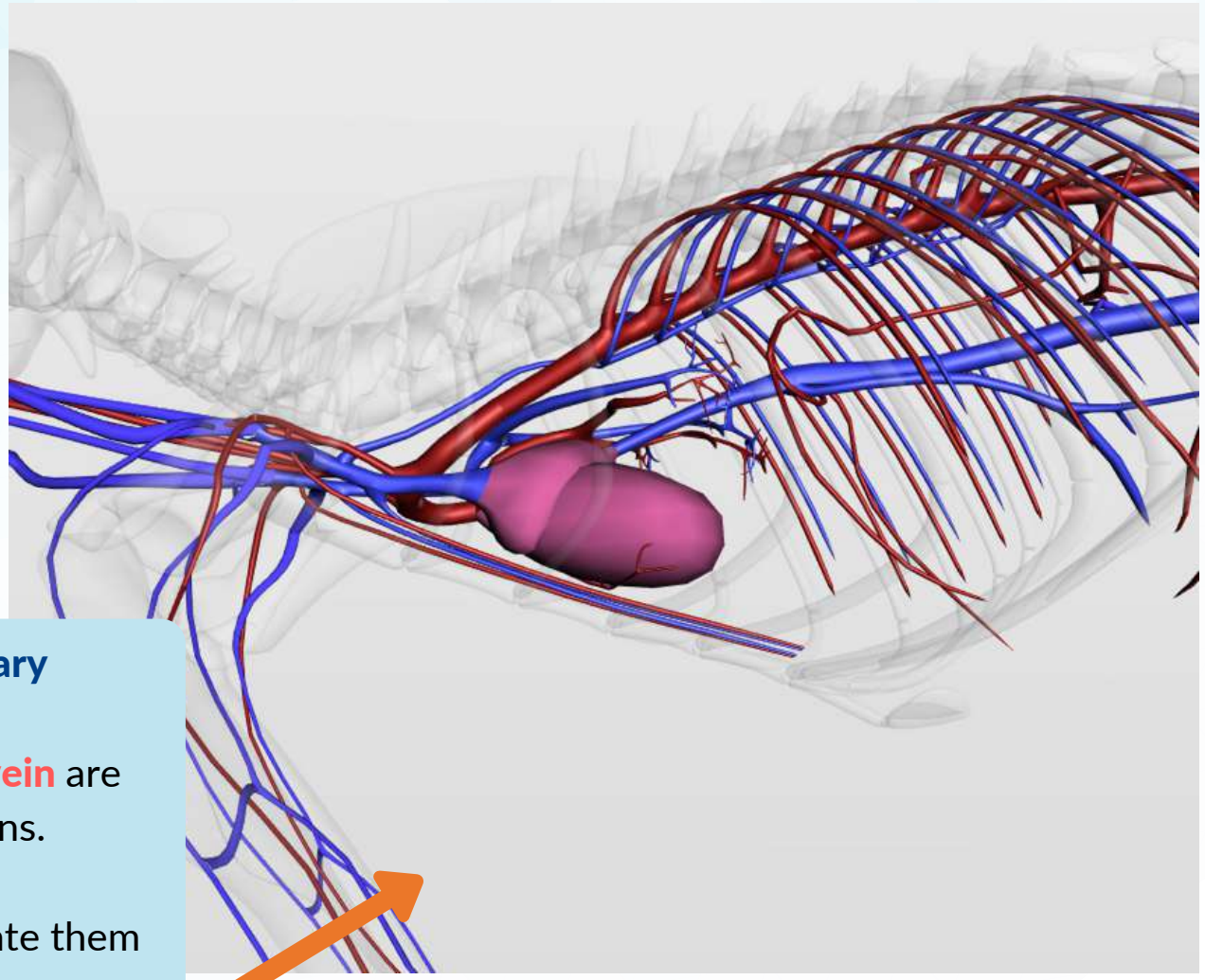
Function: **pumps blood** to lungs and the rest of the body through strong rhythmic contractions

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.

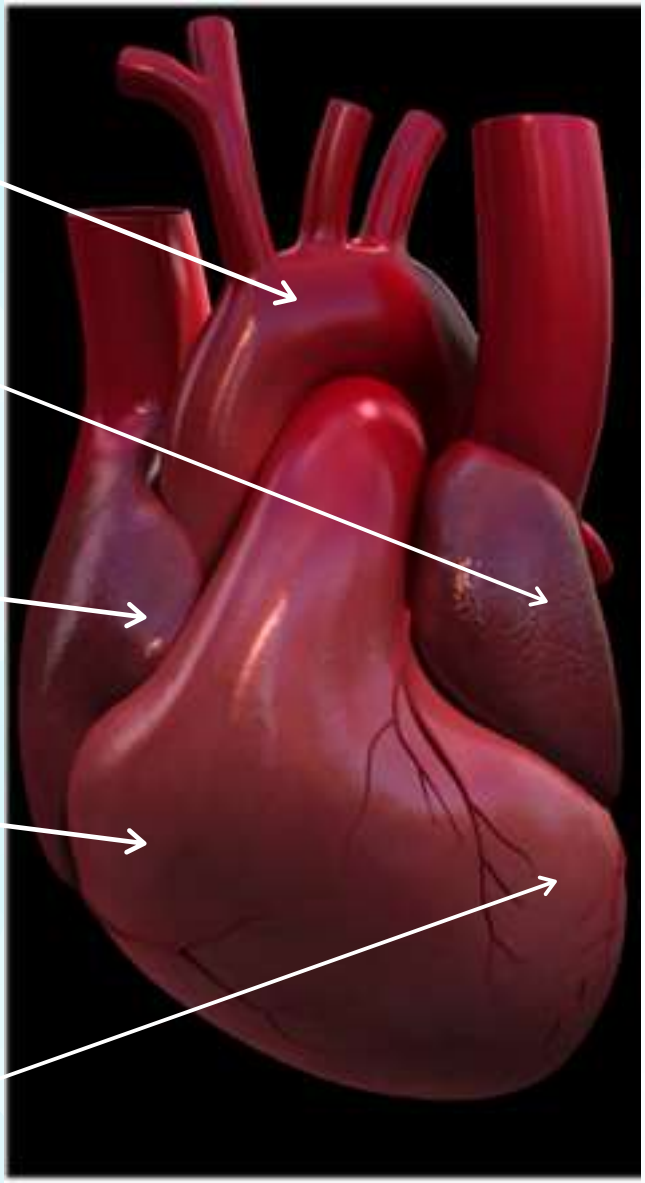
Can you locate them and label them on the image?

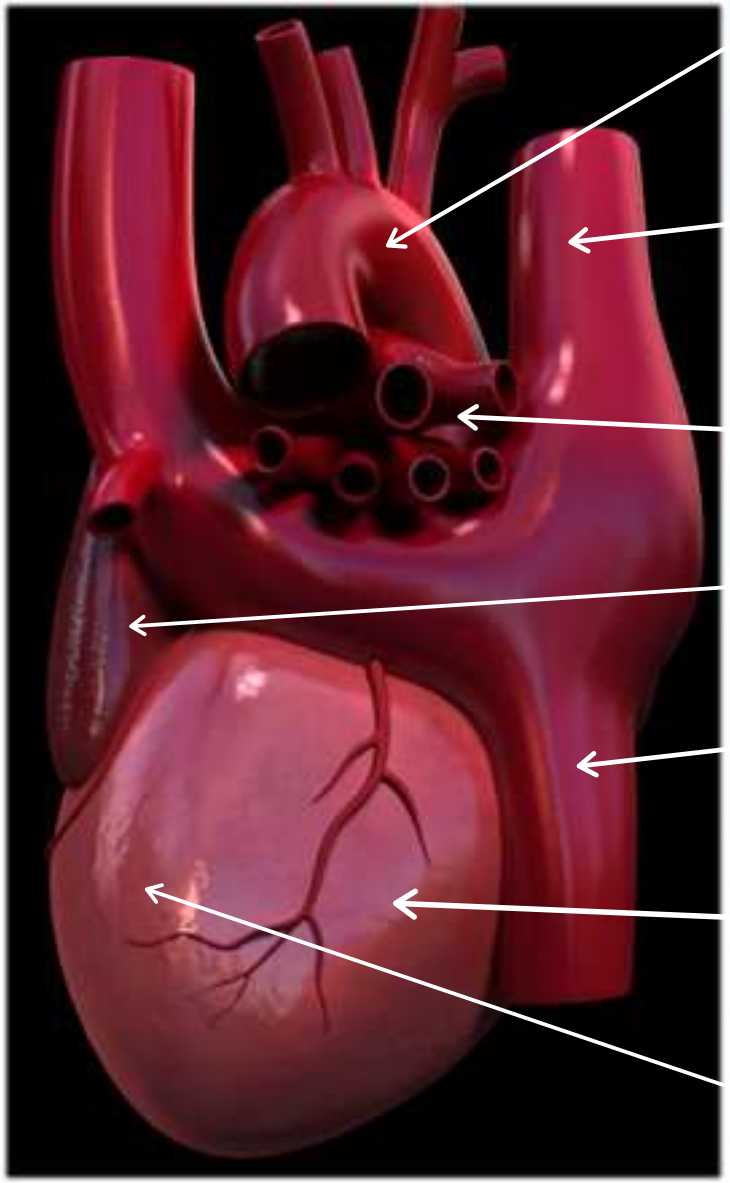


Hint - you'll need to rotate your rat so that they are sideways

The Heart

For this more detailed view of the heart, we're using screenshots from the Emantras Virtual Rat Dissection.



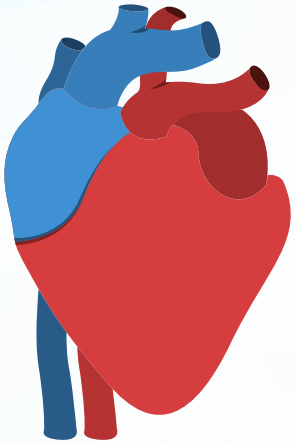


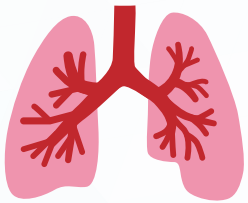
Blood Flow Through The Heart

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**

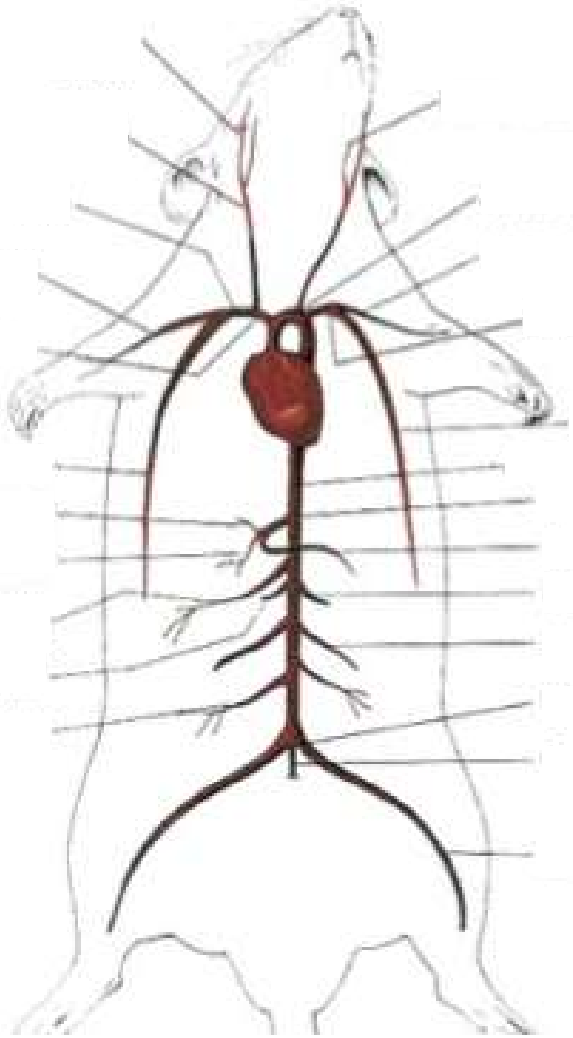
Review Break

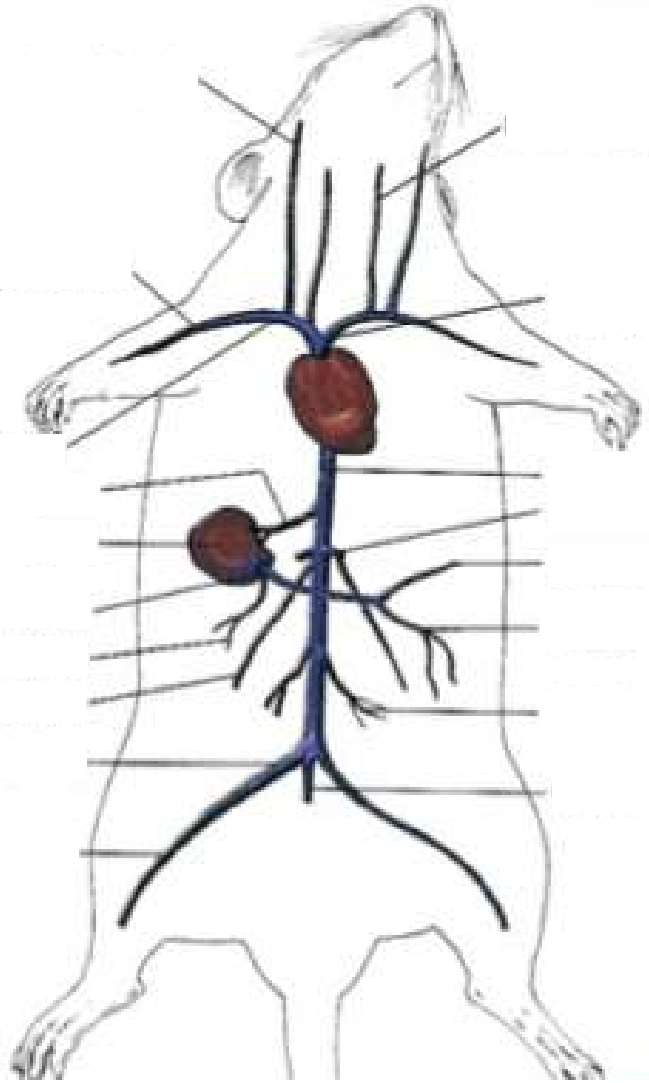
- With your group, trace the path of blood as it flows through the heart, to the lungs, and back again.

- Choose one person to explain it to the class.

QUIZ!

Label the rat circulatory system diagram below.





Urinary System

See Endocrine System for details of reproductive organs

The Kidneys

Turn off all other body systems and focus on these

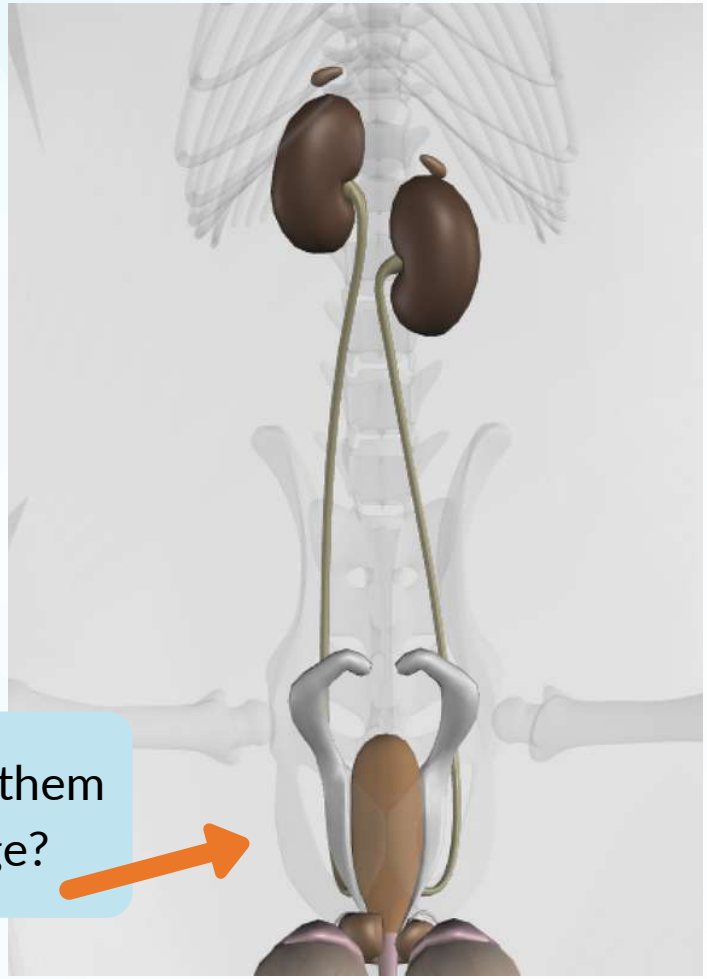
: Skeleton

::: Urogenital

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

Find the other smaller bean-shaped mass called the **adrenal glands** on the anterior end of each kidney

Can you label them on the image?



Kidneys

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

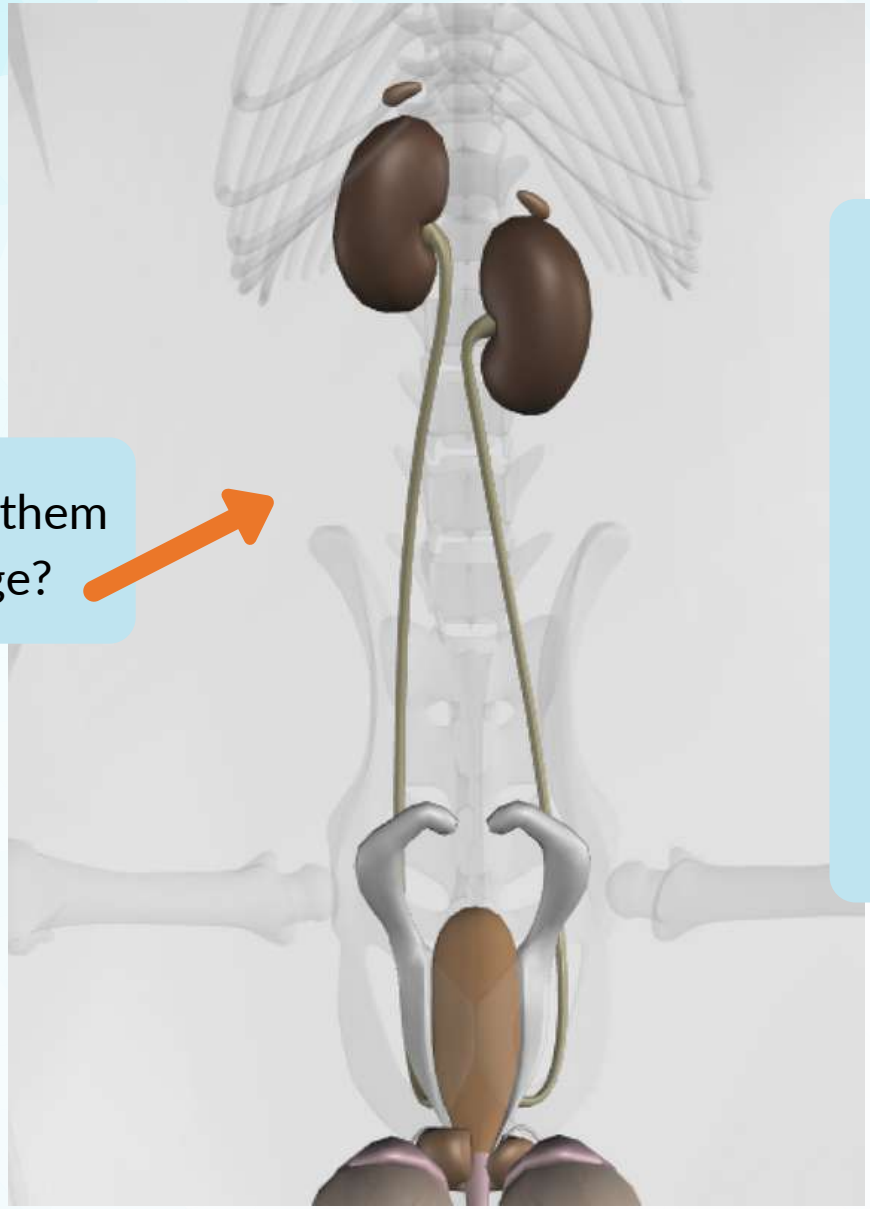
Structure: bean-shaped, surrounded by tough fibrous tissue

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

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

Can you label them on the image?

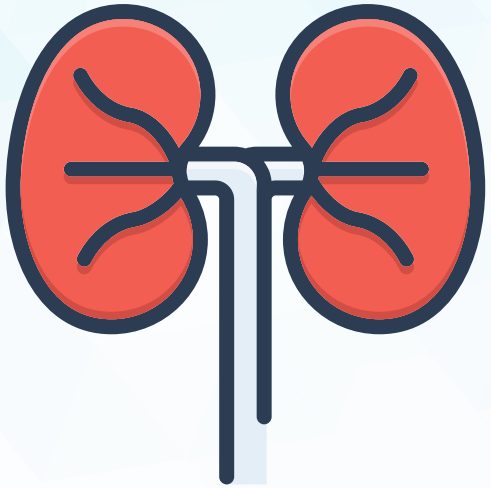
Also locate the **urethra**



Press the  button.

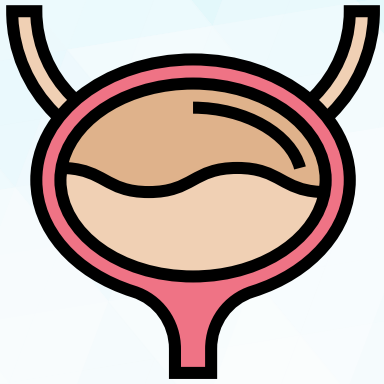
Why do you think the female and male **urethras** are different?

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 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

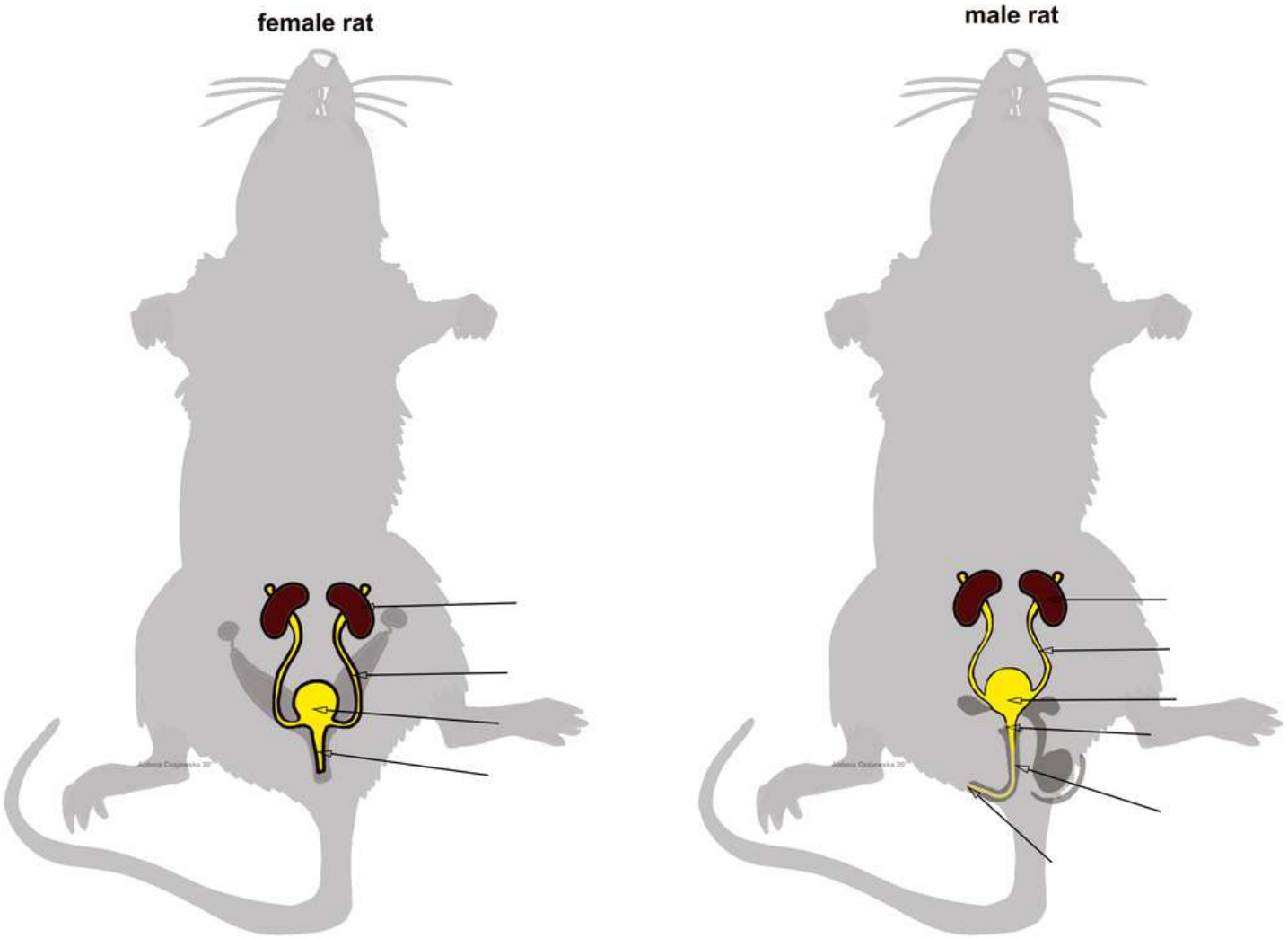
Review Break

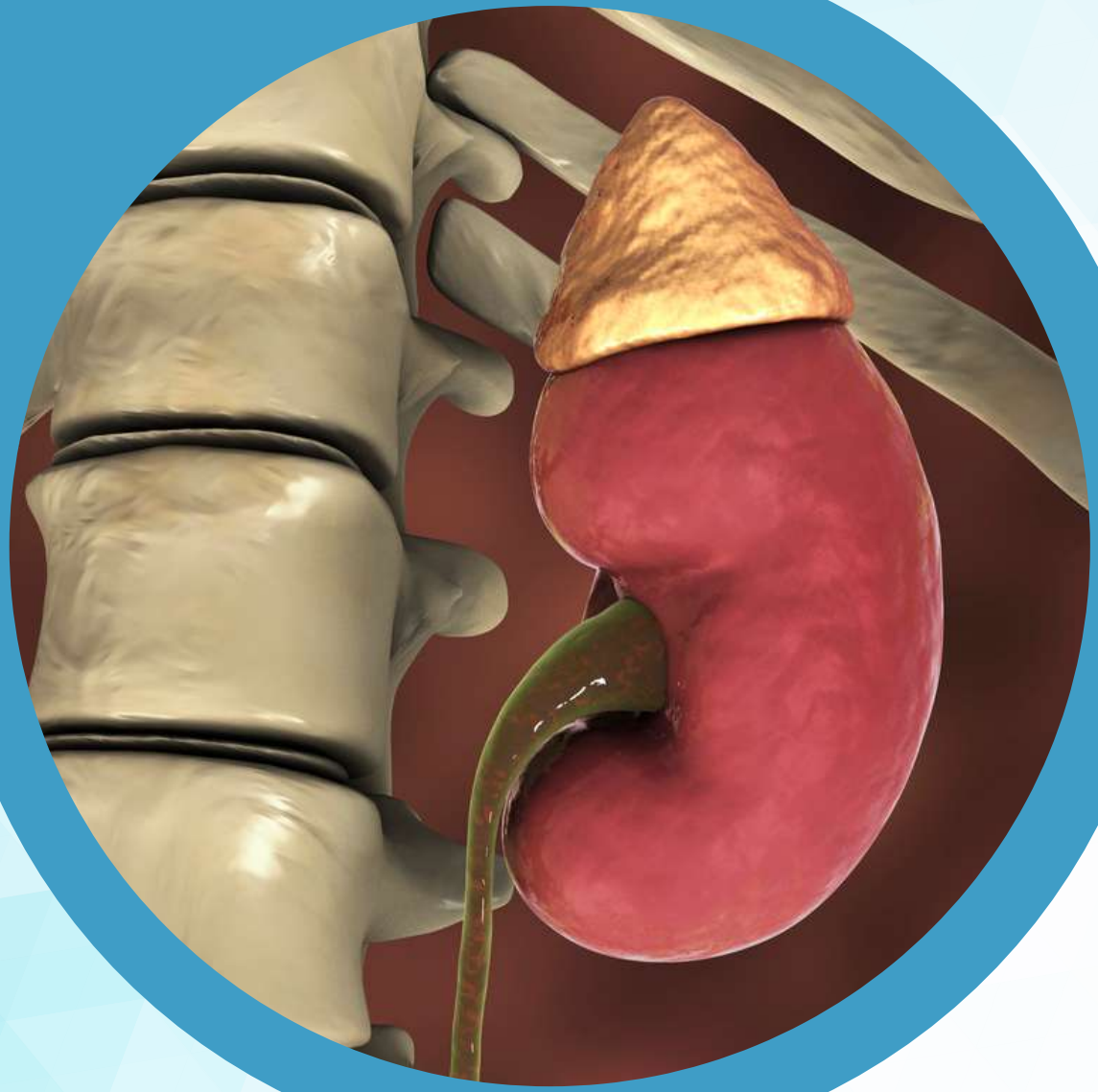
- With your group, trace the path of urine from the kidneys to the outside of the body

- Choose one person to explain it to the class.

QUIZ!

Label the rat urinary system diagram below.





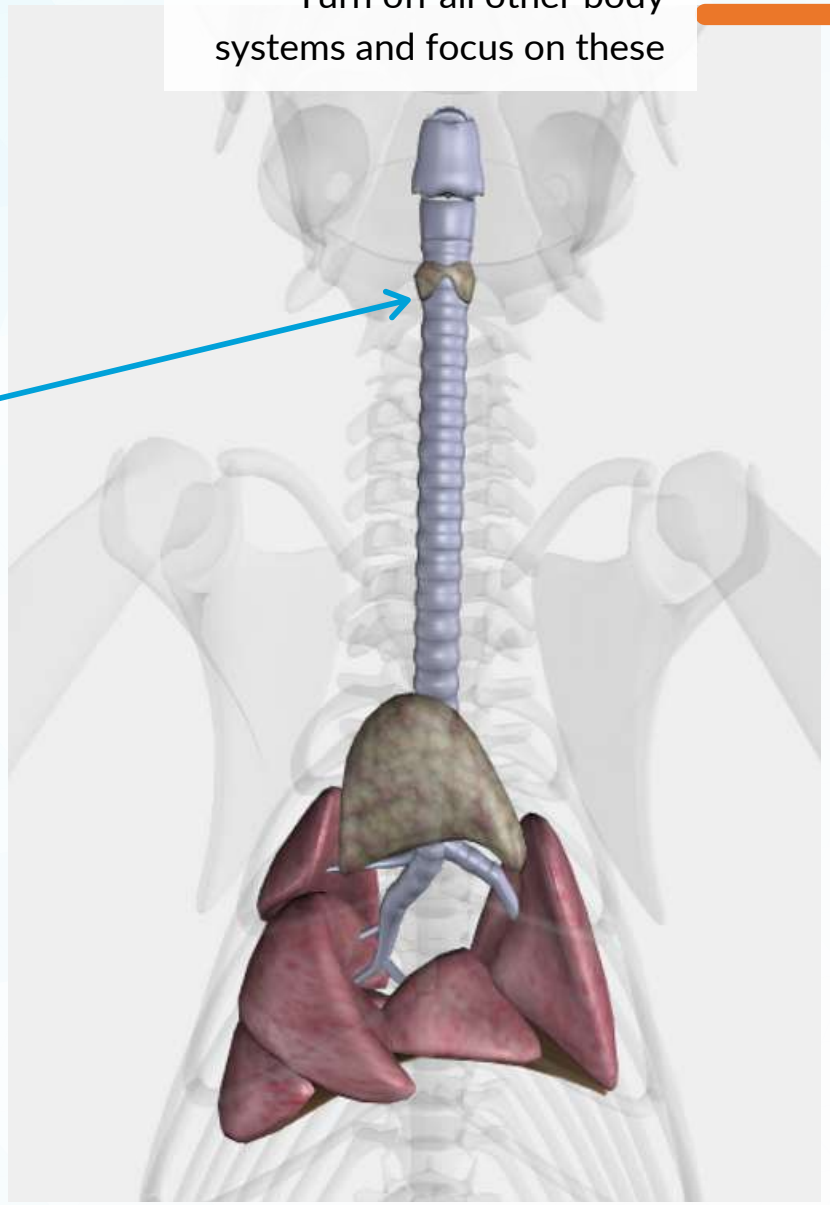
Endocrine System

Thyroid

: Skeleton

:: Respiratory

Turn off all other body systems and focus on these



Thyroid

Location: around the trachea in the throat area

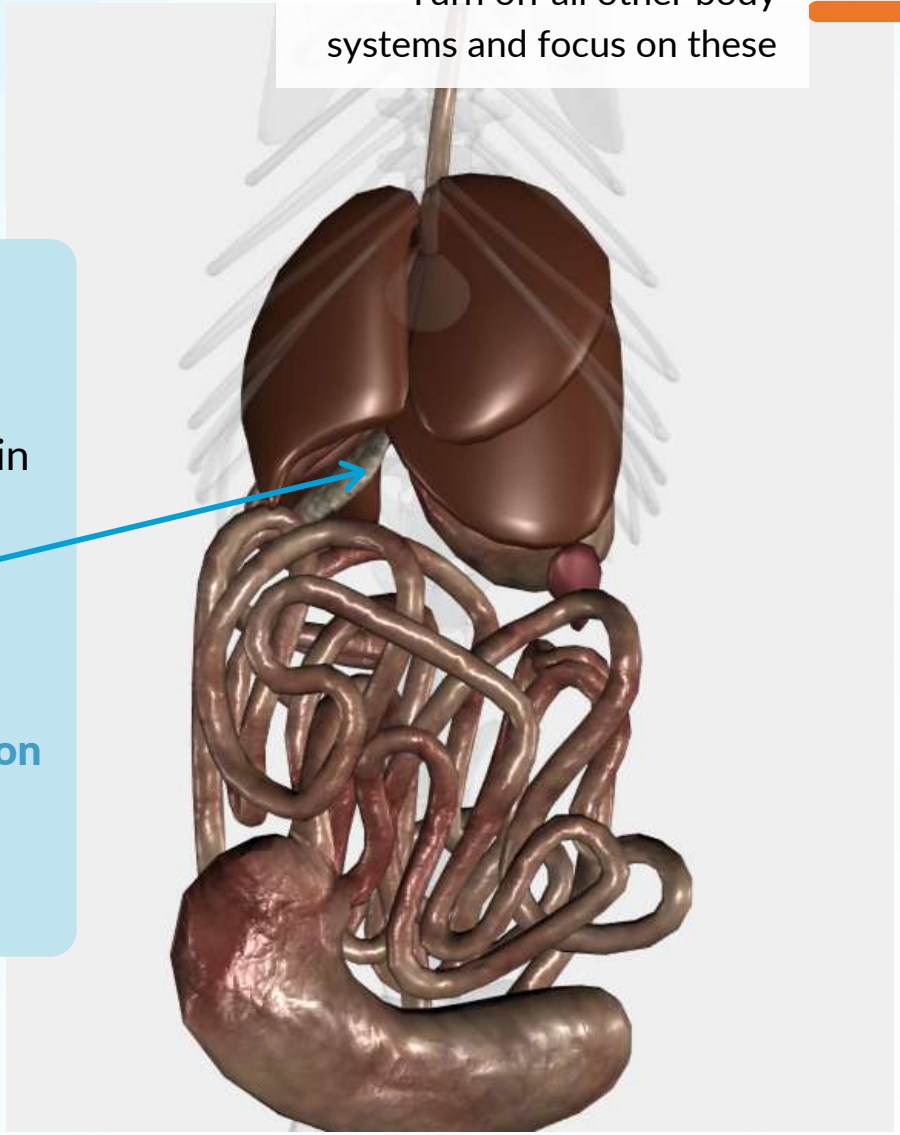
Function: produces hormones that regulate the body's **metabolic rate** controlling heart, muscle and digestive function, brain development and bone maintenance.

Pancreas

Turn off all other body systems and focus on these

: Skeleton

:: Digestive



Pancreas

Location: near stomach in abdominal cavity

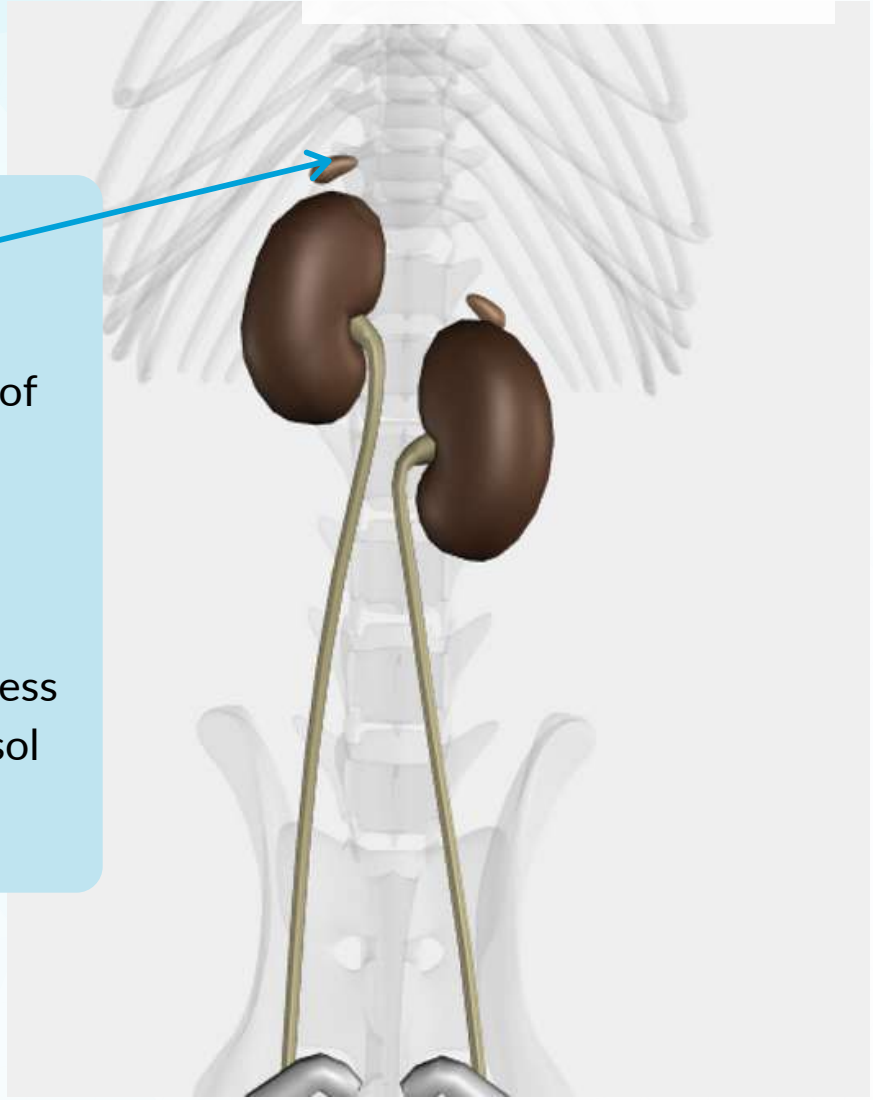
Function: **produces insulin** (which reduces blood sugar) and **glucagon** (which increases blood sugar).

Adrenal Glands

Turn off all other body systems and focus on these

: Skeleton

:: Urogenital



Adrenals

Location: anterior end of kidneys

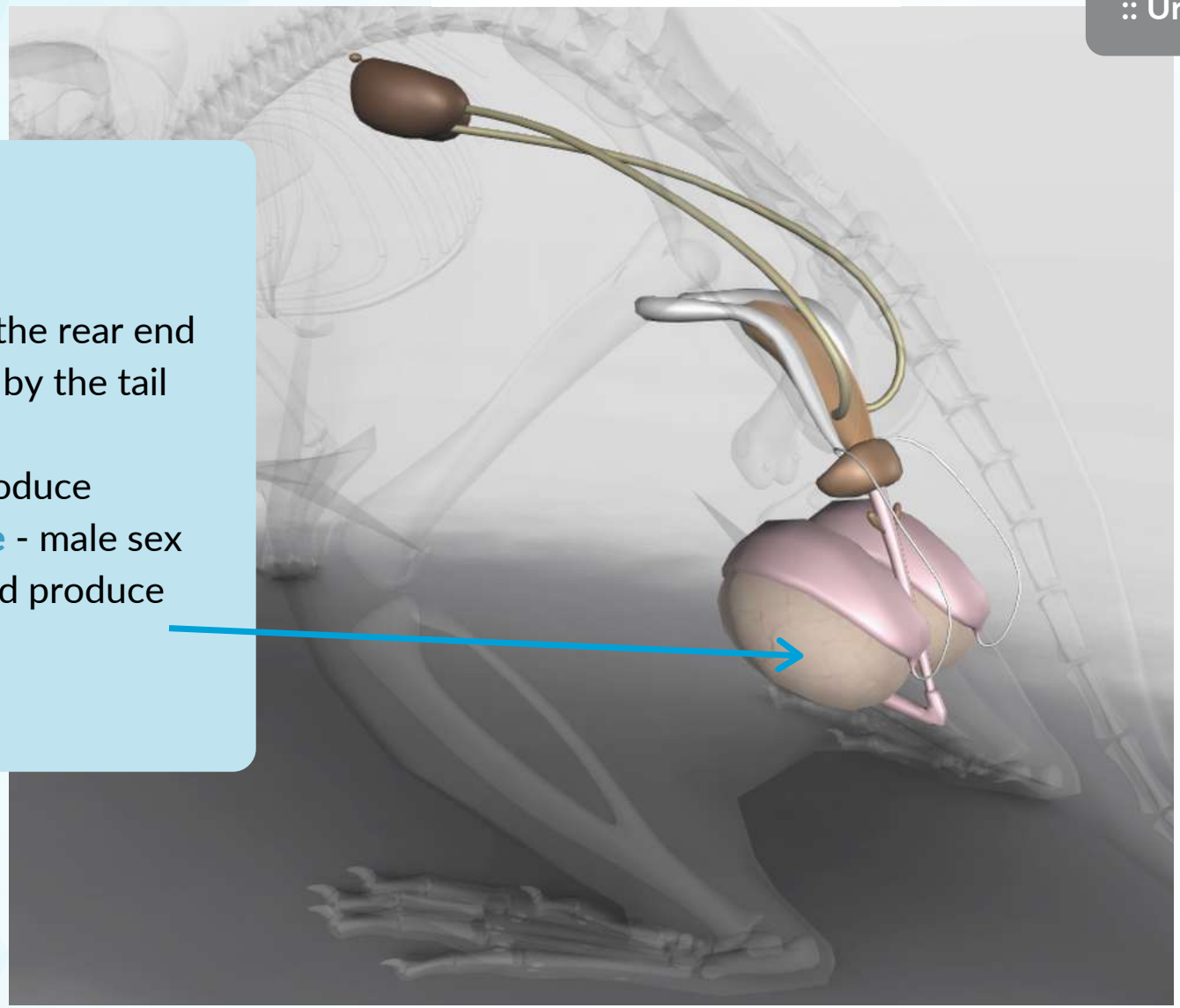
Function: produce **adrenaline** and **corticosterone** (the stress hormone - called cortisol in humans)

Testes

Turn off all other body systems and focus on these

: Skeleton

:: Urogenital



Testes

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

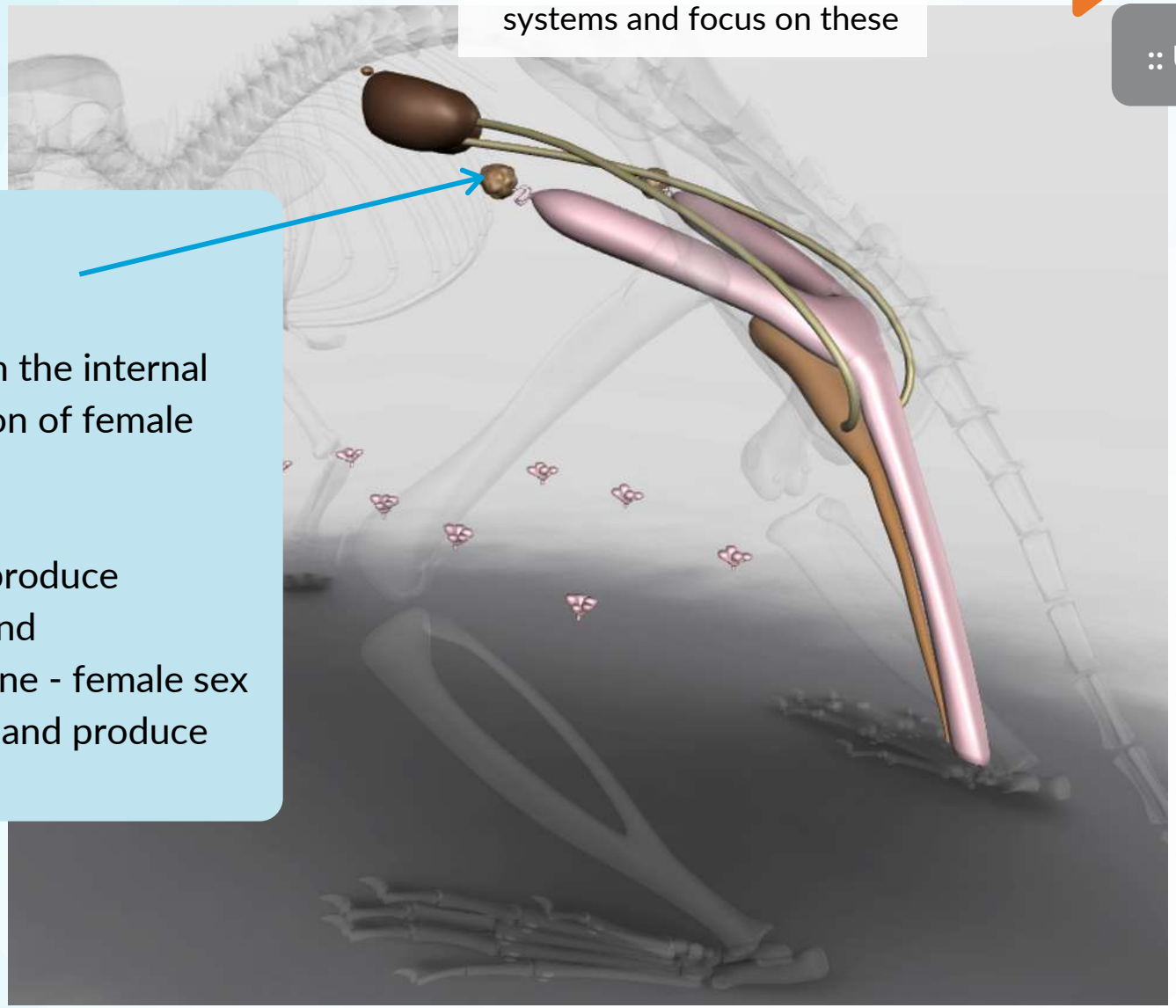
Function: produce **testosterone** - male sex hormone, and produce sperm.

Ovaries

Turn off all other body systems and focus on these

: Skeleton

:: Urogenital



Ovaries

Location: in the internal pelvic region of female rats

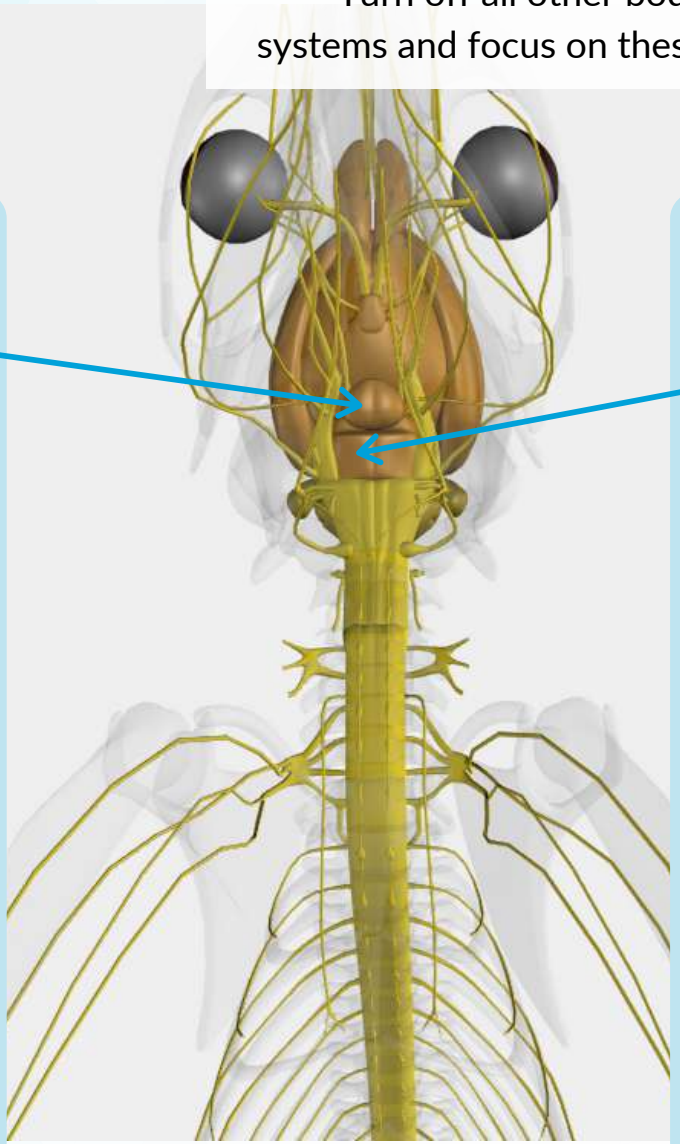
Function: produce **estrogen** and progesterone - female sex hormones, and produce eggs.

Pituitary and Hypothalamus

: Skeleton

:: Nervous

Turn off all other body systems and focus on these



Pituitary

Location: the underside of the rat 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.

Hypothalamus

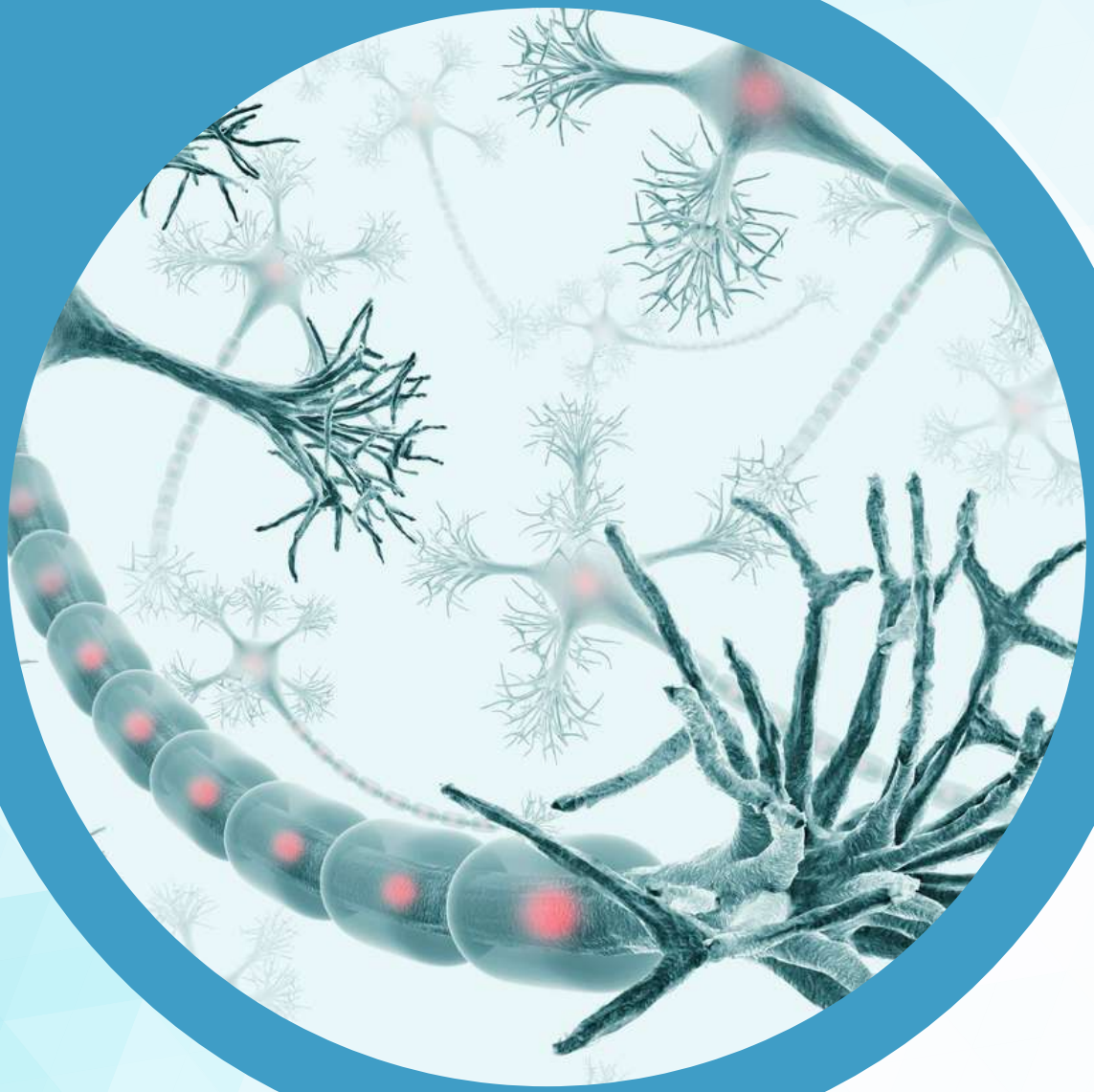
Location: the underside of the rat brain

Function: 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.

Review Break

- With your group, draw an outline of a rat's body, and then add in the major endocrine glands.

- Choose one person to explain these to the class.



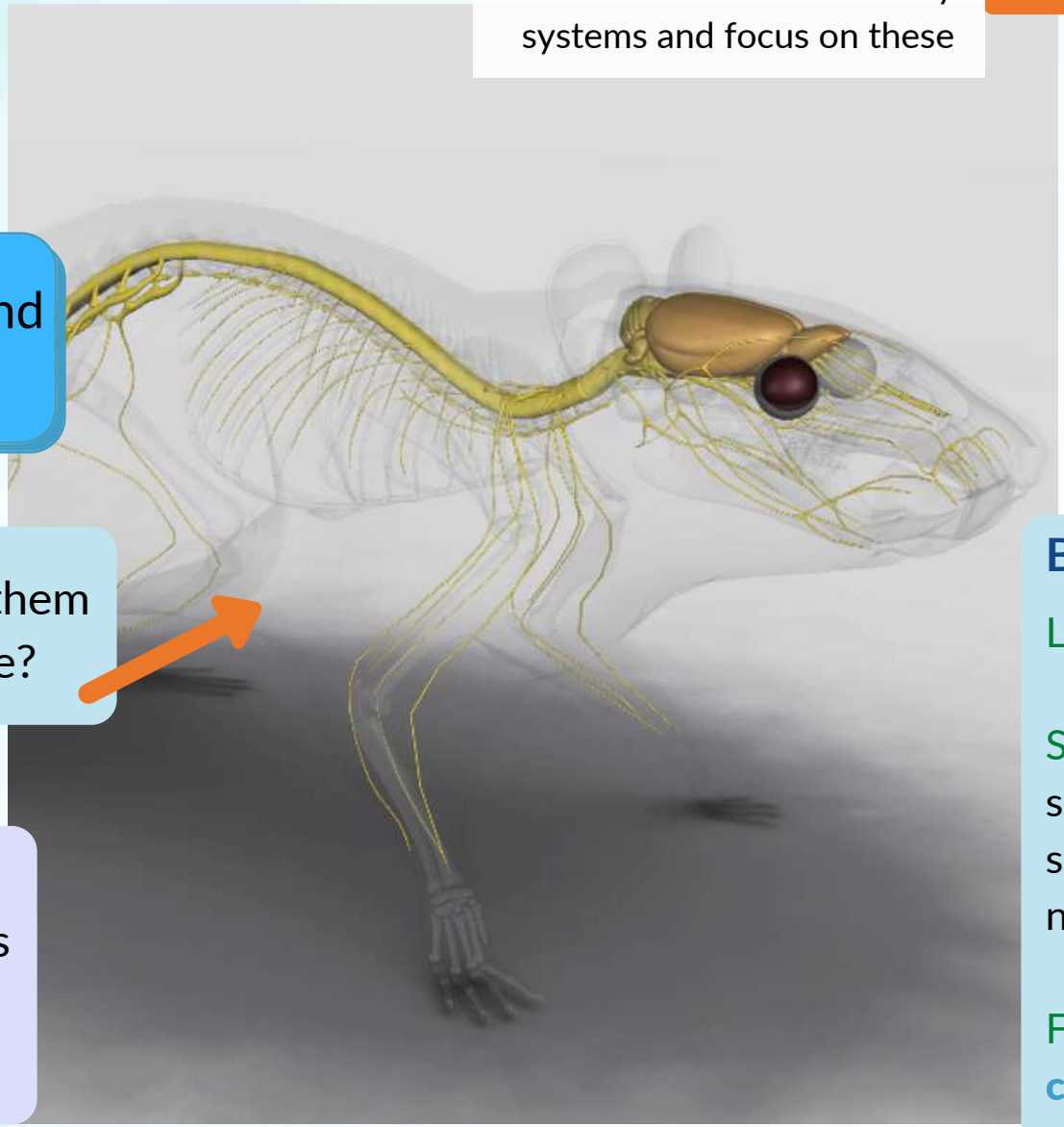
Nervous System

Central Nervous System

: Skeleton

:: Nervous

Turn off all other body systems and focus on these



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

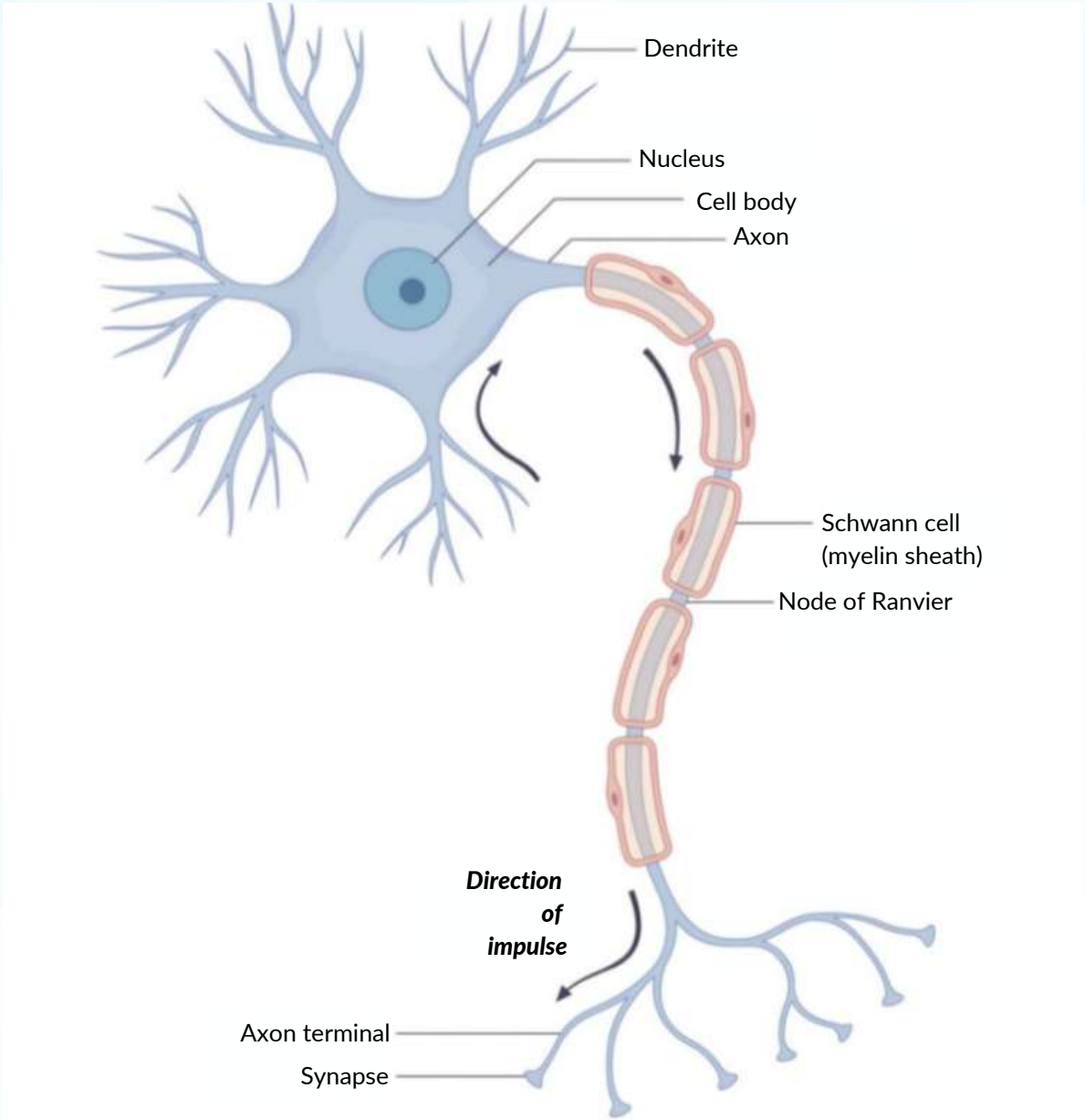
Location: in the skull

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

Function: the rat'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?!

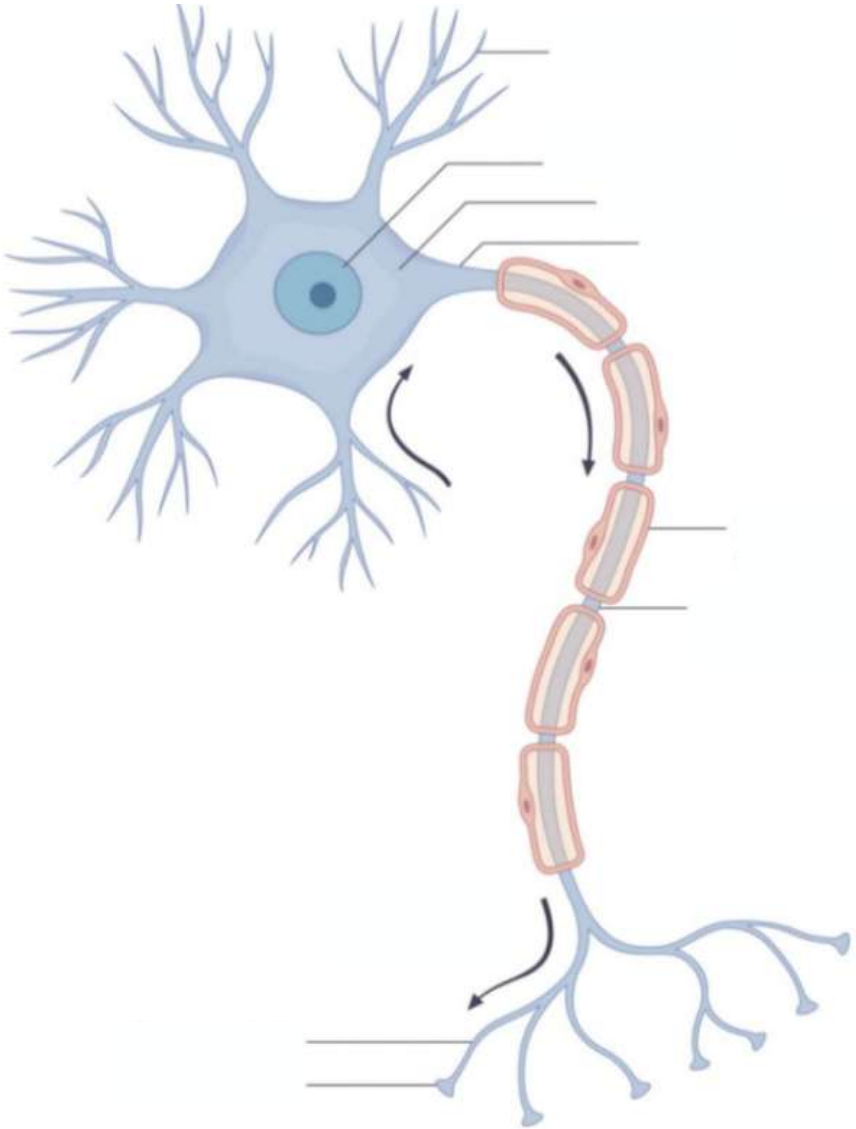


Review Break

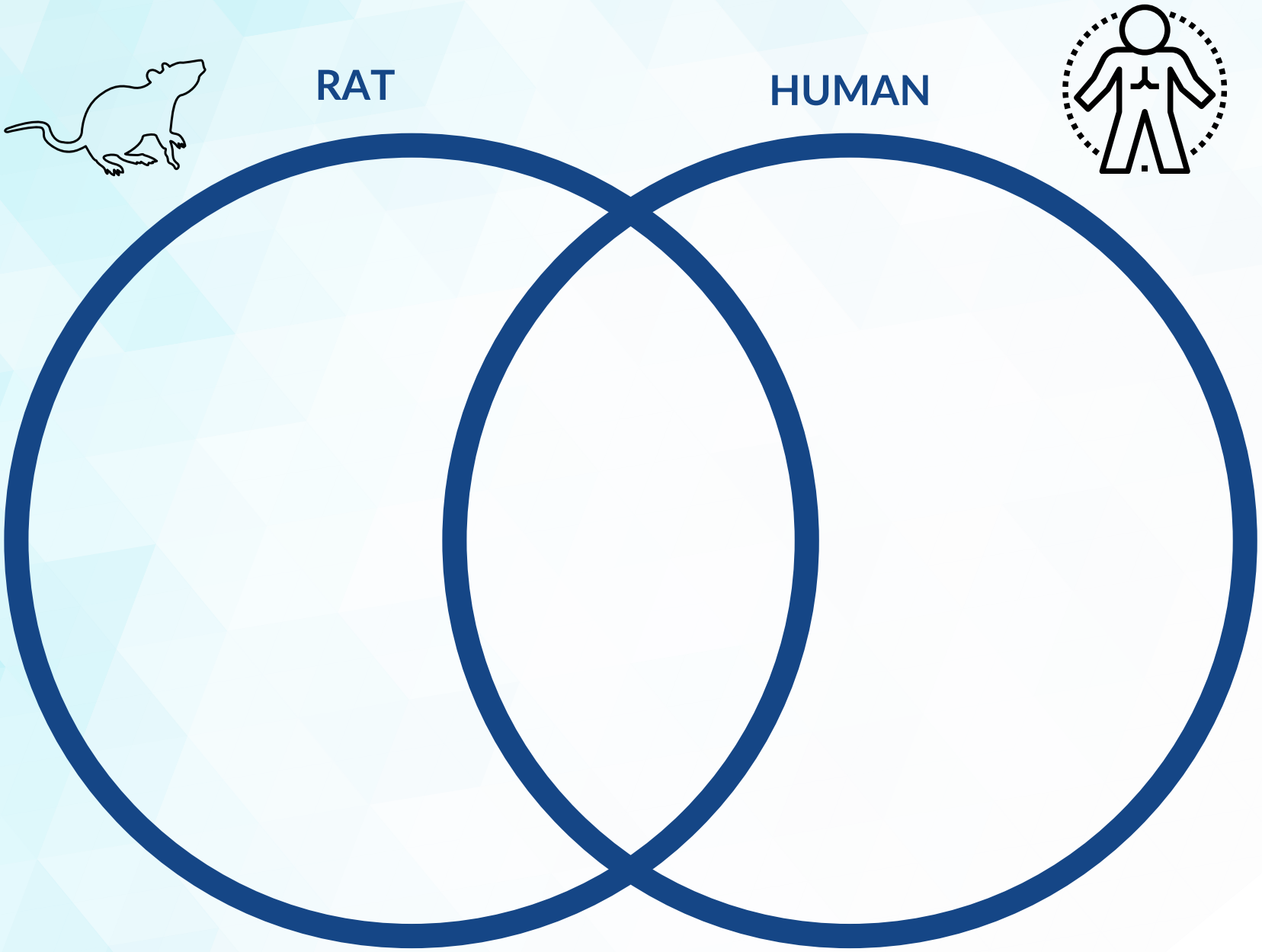
- With your group, try to draw the major features of the rat nervous system - include the brain, spinal cord, and some nerves. Can you name some of the nerves?
- With your group, draw a single nerve cell (neuron) - try to label it
- Choose one person to explain these to the class.

QUIZ!

Label the nerve cell (neuron) below.



Identify Some Key Similarities and Differences Between Rats and Humans



EXTRA STUDY QUESTIONS:

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

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

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

4. How do hormones interact with other body systems?

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

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

These materials were developed by Elisabeth Ormandy for the Canadian Society for Humane Science (2015-2022) 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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