Rat Anatomy Workbook

ACCOMPANIES 3D RAT ANATOMY APP BY BIOSPHERA
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 Rat Anatomy ......................................................................................... 6
Digestive System .................................................................................................................. 17
Musculoskeletal System ........................................................................................................ 36
Respiratory System .............................................................................................................. 40
Circulatory System ............................................................................................................ 47
Urinary System .................................................................................................................... 54
Endocrine System ............................................................................................................... 61
Nervous and Sensory System ............................................................................................. 69
Similarities Between Rats and Humans ............................................................................. 74
Extra Study Questions ........................................................................................................ 75
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 and Sensory
Getting To Know 3D Rat Anatomy
BY BIOSPHERA

The app is available for iPads, Android tablets, and desktop: 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!
ADJUST FOR DARK OR LIGHT SCREEN
CHOOSE A MALE OR FEMALE RAT
USE THESE BUTTONS TO ZOOM IN AND OUT
USE THESE BUTTONS TO MOVE YOUR RAT UP, DOWN, LEFT OR RIGHT
USE THESE BUTTONS TO ROTATE YOUR RAT IN DIFFERENT DIRECTIONS
Each grey body system button displays small dots to indicate the number of layers you can click through. Try starting with the skin layer and you'll notice that the number of dots goes 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.
Notice how the skin button now only has one set of dots, instead of two.
# Some Terms To Know

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

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
Food travels down esophagus towards stomach.

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.
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 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
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 Rat Anatomy app, but they are there!*
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 WOULD SOME CARNIVORES HAVE A VERY SMALL OR SOMETIMES NON-EXISTENT CAECUM?

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

2. 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 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

**Location:** dorsal to stomach, wrapped in the duodenum

**Structure:** flattened gland found in between stomach and small intestine

**Function:** produces two 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?

There are many hypotheses.

One of the more popular ones is that herbivores and other animals who eat low concentrations of fat, or forage continuously (ex. rats), don’t need one.

Another is that their liver might be able to concentrate higher levels of fats.
Finally, let us locate the spleen. It is an elongated, red organ found on the left side of the rat’s 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 breaks them down.
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
TURN OFF ALL OTHER BODY SYSTEMS AND FOCUS ON THE SKELETON:

Bones

Use your 3D Rat Anatomy app to label all the bones on this rat skeleton.
Use your 3D Rat Anatomy app to label the muscles on the image. Feel free to peel back deeper layers and explore deeper muscles in the app!
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

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?
Do you notice a difference between each lung?

1. The heart is located on the left side of the body.
2. 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?

1. To prevent it from collapsing as the animal inhales.
Air travels down the **trachea**, moves into each lung through the divided branches of the **bronchial tube**.

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

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

Site of **oxygen exchange**.

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

- **Breathing in**: 
  - Increase in volume means lower pressure
  - Ribs move up and out
  - Diaphragm flattens
  - Volume of chest increases

- **Breathing out**: 
  - Decrease in volume means higher pressure
  - Ribs fall
  - Diaphragm moves up
  - Volume of chest decreases
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
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 rat’s heart.

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

Can you label them on the image?
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.
For this more detailed view of the heart, we’re using screenshots from the Emantras Virtual Rat Dissection.

Heart

AORTA

LEFT ATRIUM

RIGHT ATRIUM

RIGHT VENTRICLE

LEFT VENTRICLE

SUPERIOR VENA CAVA

AORTA

PULMONARY ARTERIES

LEFT ATRIUM

INFERIOR VENA CAVA

RIGHT VENTRICLE

LEFT VENTRICLE
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**.
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
TURN OFF ALL OTHER BODY SYSTEMS AND FOCUS ON THESE:

**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.

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?
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 rat. 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
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
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

**Location:** near stomach in abdominal cavity

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

**Location:** anterior end of kidneys

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

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

**Function:** produce testosterone—the male sex hormone—and produce sperm
Ovaries

**Location:** in the internal pelvic region of female rats

**Function:** produce estrogen and progesterone—the female sex hormones—and produce eggs
Pituitary and Hypothalamus

**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.
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

**BRAIN**

**Location:** in the skull

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

**Function:** the rat’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.
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) and 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?