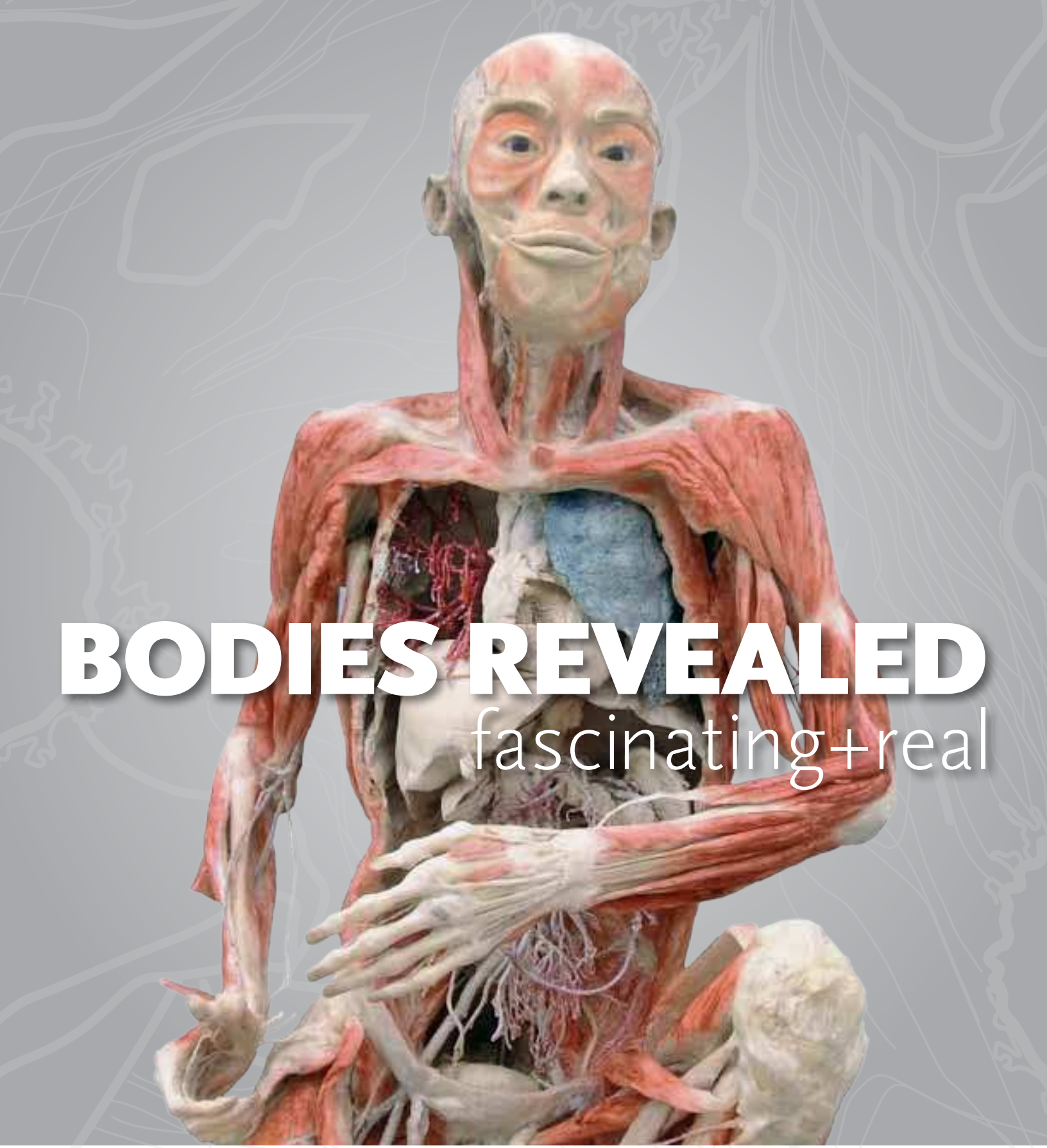


# BODIES REVEALED

fascinating+real

## Teacher's Guide

Student Activity Guide Inside • GRADES 6–8

# BODIES REVEALED
## fascinating+real

## Teacher's Guide
### GRADES 6–8


Recipient of an AAHE Distinguished Service to Health Education Award

TABLE OF CONTENTS

**CREDITS**


**Medical Director**
Dr. Roy Glover, Associate Professor Emeritus,
Anatomy and Cell Biology, University of Michigan

**Editors**
Cheryl Muré, Director of Education, Premier Exhibitions, Inc.
Terrie Nolinske, Ph.D., Vice President of Education, MOSI

**Writers: Exhibition Catalog**
Judith B. Geller, Editor, Premier Exhibitions, Inc.
John Zaller, V.P. Creative & Design, Premier Exhibitions, Inc.

**Writers: Student Learning Activities**
Anthonette Carregal, Director of Academic and Family Programs, MOSI
Anthony Pelaez, Manager of Adult and Family Programs, MOSI
Sonya Rose, Director of Group and Outreach Programs, MOSI

**Layout and Design**
Adam Englin, Graphic Design Manager, Premier Exhibitions, Inc.




**PRODUCED BY**

PREMIER EXHIBITIONS

(NASDAQ: PRXI)

# INTRODUCTION

"Why all this interest in the human body? The answer to this question seems quite clear to me: your body is the only thing you carry with you from the moment you are born until your very last breath."

—Dr. Roy Glover, Medical Director

In **BODIES REVEALED**, you will see real bodies dissected to show various systems of the human body. The Exhibition is presented in a series of open galleries following a system by system approach—the same teaching approach used by most medical schools. You will experience and have a deeper understanding of the most basic systems in your body to the most complex. You will also see individual organs or parts—some healthy, some diseased. You will observe first-hand the effect that disease and unhealthy life choices have on the body—what happens to the lungs, for example, when people smoke. You will understand how positively amazing the body is—how the pulleys, fulcrums and levers we know as muscles, joints and bones let us function continuously without even thinking about it. Also, a Resource Center is available at the end of the Exhibition, should you and your students have further questions that need to be answered and explored on your own.

**BODIES REVEALED** celebrates the human body and its inter-related systems and functions. By learning how the body works, we believe you can better care for your body and keep it healthy. By studying the systems of the body, you will come away with a new appreciation for life.

**BODIES REVEALED** provides an unprecedented opportunity for learning human anatomy, physiology, and chemistry. **BODIES REVEALED** enables you and your students to speak with ease about the body, dispelling some preconceived ideas and fears.

This Teacher's Guide is divided into sections and applies to academic content across the curriculum. First, you will find the *Teacher's Guide to Student Learning* with experiential activities aligned to the National Academic Standards. Next is the *Guide to Exhibition Galleries*, a road map to follow when you visit the Exhibition with your school group. Following is a Student Guide with Field Trip Activities along with a detailed Glossary to review and distribute.

# THE POLYMER PRESERVATION PROCESS

To help you see what a body really looks like on the inside, this Exhibition uses real human bodies that have been preserved so they do not decay.

A human specimen is first preserved according to standard mortuary science. The specimen is then dissected to highlight a specific aspect within each system of the body. Once dissected, the specimen is immersed in acetone, which eliminates all bodily fluids. The specimen is then placed in a large bath of silicone, or polymer, and sealed in a vacuum chamber. Under vacuum, acetone leaves the body in the form of gas and the polymer replaces it, entering each cell and body tissue. A catalyst is then applied to the specimen, hardening it and completing the process.

This method of preservation creates a specimen that will not decay. This offers thousands of unique teaching possibilities for educators at all levels, including medical professionals and other scientists.

# PREPARING TO VISIT THE EXHIBITION

The setting of this Exhibition lends itself to a quiet, respectful viewing of specimens. This amazing Exhibition features preserved whole human specimens and individual organs and partial body specimens. In this Exhibition all organs and body systems are on display. **BODIES REVEALED** teaches you about your body from the inside out. Students see diseased and healthy organs and learn about healthy lifestyle choices.

**BODIES REVEALED** allows students to learn about their own bodies and how to take better care of their health. The Exhibition enables students to see and understand medical conditions friends and family members face in a whole new way by highlighting pressing health concerns including smoking, cancer, cirrhosis, arthritis and fractures.

Please prepare your students by discussing what they will be seeing—real, preserved specimens of the human body. The specimens have been dissected to specifically illustrate each body system and function. Male and female reproductive organs are visible in most of the full body specimens. *The fetal gallery is entirely optional. All embryos and fetuses died of natural causes in utero.*

The specimens are preserved through a process called Polymer Preservation. This process is a revolutionary technique in which human tissue is permanently preserved using liquid silicone rubber. This prevents the natural process of decay, making the specimens available for study for an indefinite period of time. Polymer Preservation provides a closer look at the skeletal, muscular, nervous, respiratory, digestive, urinary, reproductive, endocrine and circulatory systems, unveiling the mysteries of the human anatomy. Human specimens are used instead of models to study individual variations and uniqueness.

The Exhibition offers a special children's audio tour, comprehensive Teacher's Guides for Grades K–2, 3–5, 6–8 and 9–12 plus a Post-Secondary Guide for advanced students.

# TO SEE IS TO KNOW.

# CHAPERONE RESPONSIBILITIES

As a chaperone, you are responsible for helping your students get the most out of this very unique learning experience. While some of you may be part of the teaching team at your school, others may be parent volunteers with a limited background in Biology or Anatomy. The good news is that there are trained docents in white lab coats available to answer questions throughout the galleries in the Exhibition. In addition, there are reference books at the end of the Exhibition that students are welcome to read through and thumb through as needed. Feel free to grab a book or a docent at any time during your tour.

To keep order, you need to stay with your assigned group of students throughout your visit. If you leave a gallery, they leave a gallery. If you are still in a gallery, they are still in a gallery. Please supervise your students in the retail area and in the restrooms as well.

While your students are busy learning, discovering, questioning and reflecting, we ask that you help us reinforce some basic rules of museum etiquette. Keep your voices low. Do not gather at the entrances or exits to the galleries. Do not lean against walls or block the flow of traffic for our other patrons. We have a very strict policy of no photography or cell phone use in the Exhibition. Some of your teachers may have assigned worksheets for students to complete as they move through the galleries. Please remind them not to lean on the glass cases or on the walls to write. They should use a notebook or a clipboard to fill out their papers.

We want all of our visitors to enjoy their experience at the Exhibition. Chaperones and teachers are responsible for their group's behavior. We reserve the right to remove any individual or group refusing to comply with reasonable standards of behavior.

We know that this is a fascinating Exhibition to view, but please know that your top priority is to monitor your students and keep them focused so that they can meet their teachers' expectations when they return to class.

**We greatly appreciate your participation in making this a memorable field trip for everyone from your school. Thank you!**

# SAMPLE PERMISSION SLIP

By signing this form, you are giving your child permission to view **BODIES REVEALED** on a school field trip with their teacher and chaperones.

Thank you for granting permission so that your son or daughter is able to participate in this unique opportunity to gain a better understanding about their body.

My child, _____, has my permission
(please print child's name)

to view **BODIES REVEALED** with his / her teacher and chaperones.

_____

Parent or Guardian Name (please print)

_____ _____

Parent or Guardian (signature) Date

# TEACHER'S GUIDE TO STUDENT LEARNING

### SKIN

Let's face it; the world is a tough place. It is nice to have a flexible, self-repairing, multi-sensory suit of armor that shields you from the elements and protects your vital organs from microbial invaders and physical harm. Many people are surprised to learn that skin is an organ. In fact, it is the human body's largest organ.

Specialized cells known as melanocytes produce melanin, the chemical pigment that gives skin its color. People with light colored skin and dark colored skin have the same number of melanocytes. The only difference between them is the activity level of melanin production. Melanin helps to protect the body from the harmful effects of UV light from the sun.

**Did you know?**

Although our skin does help to protect our bodies from UV light, it is important to use sun block rated at SPF 45 or more on exposed areas of your body to prevent sunburn, premature wrinkling and skin cancer.

# ACTIVITY What is Warm & What is Cold?

Students will compare if something is hot or cold relative to the temperature of the skin.

## INTRODUCING THE ACTIVITY

When we say something is hot or cold, we are usually thinking in terms of its comparison to something else. Boiling water isn't very hot compared with molten steel, for instance. We sometimes get a glass of water from the cold-water tap and complain about the water being warm, but if we were to take a shower in water of the same temperature we would probably consider it very cold. This activity is designed to point out that our reactions to temperatures are relative. We frequently judge something to be hot or cold relative to the temperature of the skin. The lukewarm water used in this activity should be such that it feels neither hot nor cold to the skin.

## MATERIALS (per pair of students)

- three pans or bowls
- hot, lukewarm, and cold water
- blindfold

## PROCEDURE

1. Fill one pan with cold water, one with lukewarm water, and one with hot water.
2. Blindfold your partner.
3. Have your partner put the left hand in the hot water and then put the right hand in the lukewarm water.
4. Ask your partner to describe the temperature of the water in both bowls.
5. Have your partner remove both hands from the water.
6. Shift the bowls around, and then have your partner put the left hand in the cold water and the right hand in the lukewarm water.
7. Ask your partner to again describe the temperature of the water in the two bowls.
8. Repeat steps 1–7 with the other partner and compare results.

## EXTENSION

**Be SunWise.** Check out the U.S. Environmental Protection Agency's SunWise Program about how to be protected from overexposure to the sun through a variety of educational programs. http://www.epa.gov/sunwise/

# TEACHER'S GUIDE TO STUDENT LEARNING

## SKELETAL SYSTEM

If you have ever seen an X-ray taken by a doctor, you probably realize that everyone has a skeleton made up of many bones. In fact, the average adult has about 206 of them—over half of them in your hands and feet. Your skeleton gives your body structure like the girders of a building. The bones of your skeleton also protect your internal organs, such as your heart, brain and lungs.

Many people think that the skull is one big piece of bone, but in truth it is composed of 30 different bones.

Follow these tips if you want to have strong and healthy bones:

- Protect your skull bones and the brain inside by wearing a helmet whenever you bike, skateboard or roller skate. Also, wear appropriate gear such as elbow and kneepads to give you extra protection if you fall.
- Strengthen your skeleton by getting plenty of calcium through drinking milk and eating other foods high in calcium. Check out the nutritional labels on the foods you eat to see which are highest in calcium.

Joints, made up of ligaments and cartilage, link one bone to another. Joints that do not move are known as fixed joints and can be found connecting the sides and front of the skull. Moving joints allow for a wide range of motions depending on their purpose. Our elbows and knees are examples of hinge joints while our shoulders and hips allow for motion in many different directions.

### Did you know?

What really happens when you crack your knuckles? Joints are the meeting points of two separate bones held together by connecting tissues and ligaments. A thick, clear lubricant (made mostly of carbon dioxide and some nitrogen) called synovial fluid is found between the bones. When you stretch or pull your fingers, bubbles of gas form quickly and burst—which is why you get that cracking noise.

Bones of the hand

# ACTIVITY Bones, Bones & More Bones

Students will recognize that hollow bones have more strength than solid bones.

## INTRODUCING THE ACTIVITY

The skeletal system of the human body is made up of bones. These bones create the body's shape and protect internal, delicate body parts. An adult person has about 206 bones in his/her body. The number of bones in a person's body varies due to the discrepancies in the number of little bones in the hands and feet.

## MATERIALS (per group of students)

- 6 sheets of 8 ½" x 11" paper
- 1 roll tape
- 2 paper plates
- 1 measuring cup
- 20 weights (small blocks)

## PROCEDURE

1. Roll up a sheet of paper (8 ½" x 11") about 1 inch wide into a cylinder. Make 3 of these "paper bones" to test.
2. Stand the bones up on their ends. Place a paper plate on top of the bones.
3. What's happening? The hollow rolls will support the plate.
4. Begin to add weights (wooden blocks) to the plate.
5. Count how many blocks the plate can hold before the bone collapses.
6. Have students roll 3 more sheets of paper as tightly as they can so that there is no hollow section.
7. Students will stand these "bones" up as before, placing the same plate on top of them.
8. Students will place weights on top of the plate until they collapse.
9. Record results. Compare with others.

## EXPLANATION

Hollow bones are able to support more weight. Having a hollow center gives the bone a better design and makes it stronger. The large bones in our body are also hollow. This makes them both strong, so they can support more weight, as well as light, so it takes less energy to move them.

# ACTIVITY Bones, Bones & More Bones

Students will recognize that hollow bones have more strength than solid bones.

## EXTENSION

1. Why are the "hollow bones" able to hold more weight?

2. Learn the parts of the skeletal system. Sing this song:

**DEM BONES ARE ALIVE!**
(sung to the tune of "Dem Bones")

*Chorus*
Dem Bones, Dem Bones, Dem Strong Bones
Dem Bones, Dem Bones, Dem Healing Bones
Dem Bones are alive!

The metatarsals are connected to the tarsus
The tarsus is connected to the fibula
The fibula is connected to the patella
Dem Bones are alive!

*Chorus*
The patella is connected to the femur
The femur is connected to the pelvis
The pelvis is connected to the sacrum
Dem Bones are alive!

*Chorus*
The sacrum is connected to the vertebral column
The vertebral column is connected to the occipital bone
The occipital bone is connected to the cranium
Dem Bones are alive!

*Chorus*

# TEACHER'S GUIDE TO STUDENT LEARNING

## MUSCULAR SYSTEM

If all 600 muscles in your body pulled in one direction, you could lift around 25 tons. But lifting things is just one of the jobs our muscles help us do. Muscles pump blood through our body, allow us to smile or frown, and help us to run and jump. The muscular system is made up of three types of muscles:

**Smooth muscles.** Muscles that work automatically, without conscious thought, are involuntary or smooth muscles. Smooth muscles are made up of smooth muscular tissue. They control the involuntary movements of the internal organs (i.e. blood vessels, bronchi, digestive tract, and uterus). The smooth muscles found in our digestive system help us digest by squeezing food from the esophagus to the rectum using the process called peristalsis. Smooth muscles are capable of staying contracted for long periods of time.

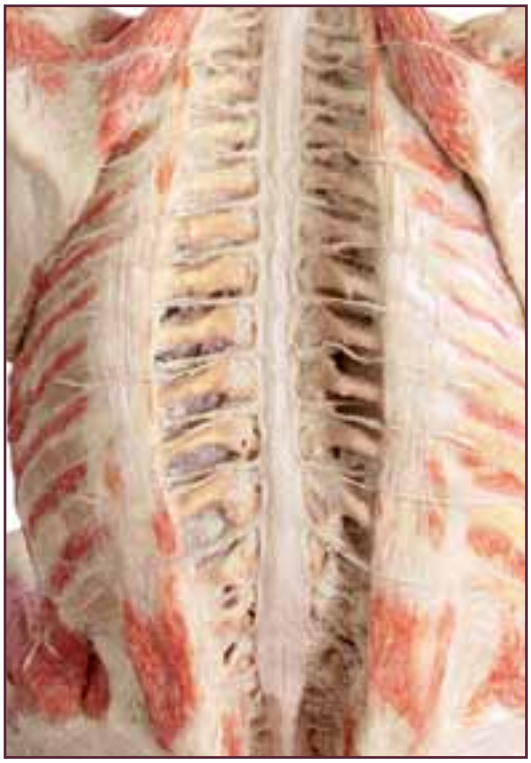
One of the locations smooth muscle can be found is the gastrointestinal tract.

Cardiac muscle in the ventricular wall

**Cardiac muscles.** Our hearts are made of cardiac muscle designed to squeeze blood to all the systems of our body through blood vessels. The cardiac muscle is made up of cardiac fibers laid into spiral bundles. Each cell can contract rhythmically. The entire tissue contracts in a coordinated fashion due to a particular anatomical element from which, "waves" of contraction emanate. These waves spread to the heart, regulating its beat. The cardiac muscle is able to sustain strong and continuous contractions without getting tired.

# TEACHER'S GUIDE TO STUDENT LEARNING

**Skeletal muscles.** Skeletal muscles, the muscles most people identify with, are voluntary muscles that we control. They make up the musculoskeletal system. Skeletal muscles are made up of striated muscle tissue. They insert into your bones. Skeletal muscles are able to contract with great strength, but they tire easily.



Spinal cord exposed

**Muscle contraction.** The act of lifting an object is not a simple process. When we use our muscles for physical movement, we call upon our skeletal muscles. Skeletal muscles contract when the brain sends signals in the form of "action potentials" through the nervous system.

The place where the nerve and muscle meet is called the neuromuscular junction. An electrical signal crosses this junction and triggers the flow of calcium ions causing the myofilaments, fibers made from protein, to slide across one another. When this happens, the sarcomere, a thick filament system that gives cardiac and skeletal muscles their striped appearance, shortens and force is generated.

Billions of sarcomeres shortening cause a contraction of the entire muscle fiber. An energy supply of ATP (adenosine triphosphate), the body's primary energy unit, ensures continued muscle contraction.

## Did you know?

Calcium is not just needed by the bones in your body. Muscles do not contract as well without a supply of calcium ions.

# ACTIVITY Muscle Stamina

Students will learn about muscle stamina and what happens to muscles when they become fatigued.

## INTRODUCING THE ACTIVITY

Explain to students that muscles help the body move. Muscles require food, water and oxygen to do this work. You use muscles every day to do things like breathe, walk, eat and digest your food. Muscles that are used on a regular basis become stronger and can work for longer periods of time without becoming fatigued. They develop increased stamina.

These muscles become larger and their blood vessels become wider. A muscle exercised strenuously for a prolonged period of time may lose its ability to contract, a condition called fatigue.

Muscle fibers contract many times per second. Sometimes your body cannot supply food, water, and oxygen fast enough for your muscles. You begin to breathe harder and your heart beats faster trying to meet the needs. Your body is able to make a little muscle energy without oxygen.

When this happens, lactic acid is produced and collects in the muscles. As the lactic acid increases, it becomes harder for the muscles to contract. Eventually, the muscles get tired and refuse to work until they have had time to rest. Your body needs oxygen to get rid of the lactic acid in your muscles. Your heart will continue to beat fast and you will continue to breathe deeply until this need is met.

## MATERIALS (per pair of students)

- 1 stopwatch
- 1 spring clothespin
- notebook for recording data
- 2 sheets large graph paper

## PROCEDURE

1. Pick up your clothespin and count how many times you can rapidly open and close the clothespin in 30 seconds (each opening and closing should be counted as one action).
2. Record the results in your notebook.
3. Without resting between trials, repeat the test four more times and record results for each trial.
4. Graph the results of each of the trials.

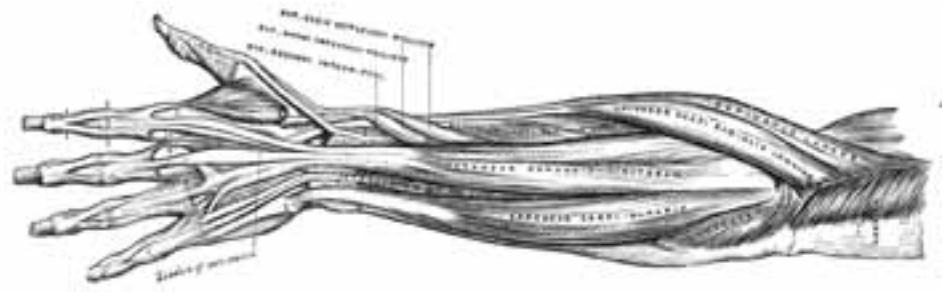
## EXPLANATION

Muscles use food, water, and oxygen to produce energy to do work. With prolonged work, the energy needs of the muscles become harder to meet and the muscles become fatigued.

Therefore, as the number of trials increases, the muscles begin to tire and the number of actions decreases.

## EXTENSION

1. Have students compare their results and discuss what happened as trials were repeated.
2. Have students discuss whether or not the results would have varied if some factors were changed. For example, if they opened and closed the clothespin for 1 minute instead of 30 seconds or if students had 5 minute rest periods between each trial.



# TEACHER'S GUIDE TO STUDENT LEARNING

## NERVOUS SYSTEM

Let's say you are walking in a dark room when suddenly you see something move in the corner. Your eyes send that information to your brain, which reacts to possible "danger" by sending impulses to prepare the body for action. Your heart might beat faster as your muscles are prepared to retreat or protect yourself. This is an example of the "fight or flight" response and represents one of the ways our nervous system looks after our survival.

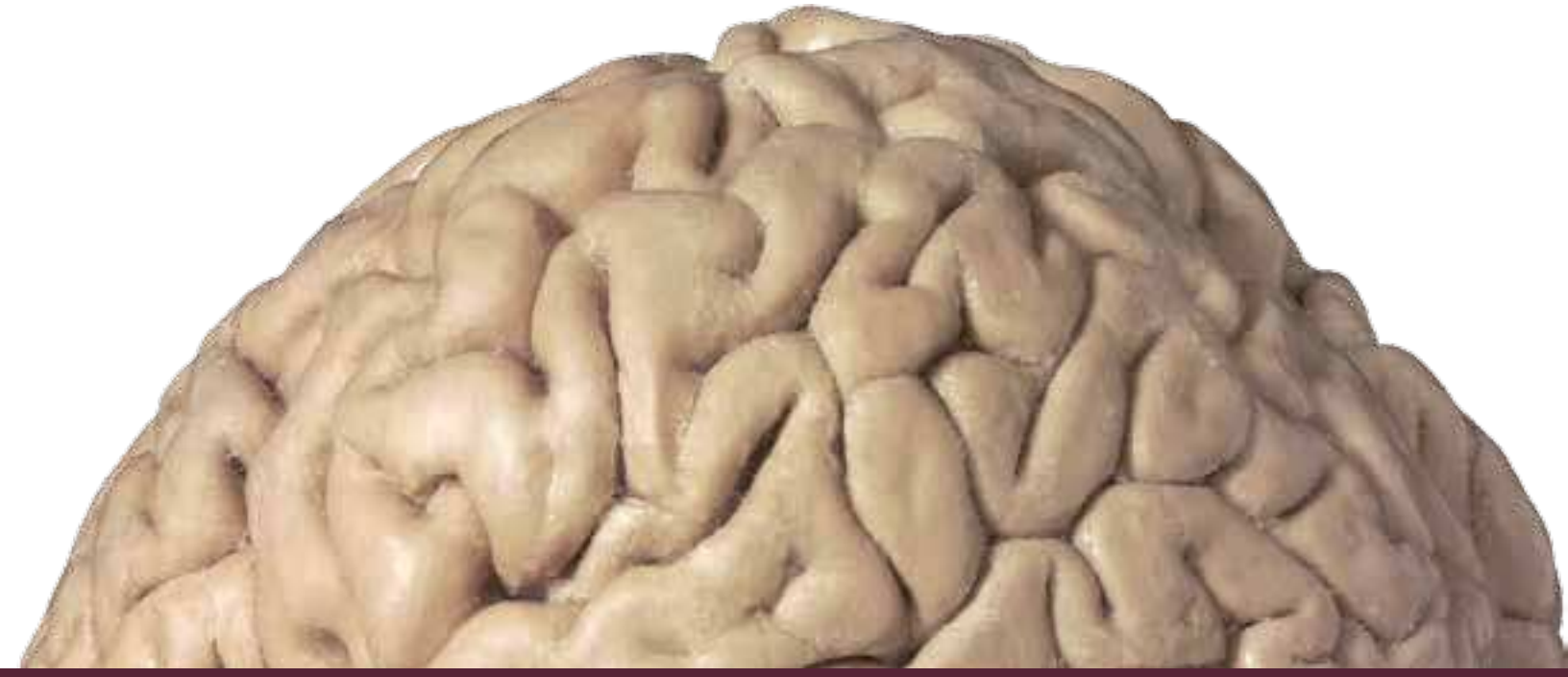
The nervous system is like the Internet of the human body. It gathers, stores and transfers information to control systems throughout the body. The nervous system is designed to prepare and adapt your body to a wide variety of situations and environments.

Your nervous system is divided into the central nervous system (the brain and spinal cord) and the peripheral nervous system (the nerves that move information into the arms and hands and to the legs and feet).

The autonomic system innervates our organs, things that we do not even think about, like our heart, kidneys or our digestive system. The somatic system is made up of motor fibers and sensory fibers.

### Did you know?

The speed at which nerve messages travel can be as fast as 270 miles per hour.



# ACTIVITY Spinal Reflexes

Students will demonstrate reflex responses to sensory stimulation.

## INTRODUCING THE ACTIVITY

Reflexes are rapid, involuntary responses to stimuli which are mediated over simple nerve pathways called reflex arcs. Involuntary reflexes are very fast, traveling in milliseconds. The patellar reflex is a true spinal reflex. It involves only neurons in the body and spinal cord and completely bypasses the brain. The patellar reflex is a normal, healthy reflex that involves the contraction of the quadriceps and extension of the leg when the patellar tendon is tapped.

## MATERIALS (per pair of students)

- 1 lab stool or chair
- 1 reflex mallet (if not available, try to use the outside edge of your hand)

## PROCEDURE

1. Have your partner sit on the lab stool with one leg crossed.
2. Sharply tap the patellar tendon of the crossed leg with the blunt side of the reflex mallet and note the response. Compare responses in the right and left knees.
3. Diagram and label the reflex arc in your lab report.
4. Repeat step one, but have your partner perform Jendrassik's maneuver:
   a. clasp his or her hands at chest level in front of your body with your fingers locked
   b. have him or her try to vigorously to pull the hands apart while you tap the patellar tendon as before.

## EXPLANATION

Students should notice a larger reflex when performing Jendrassik's maneuver.

## EXTENSION

1. Discuss differences between the patellar reflex and Jendrassik's maneuver.
2. Compare results and discuss the differences in the reflex locations.

This is the central nervous system; the brain and the spinal cord.

# TEACHER'S GUIDE TO STUDENT LEARNING

### CIRCULATORY SYSTEM

Your circulatory system is like the highway system of your body. Vital nutrients and oxygen are transported in the blood flowing through your arteries. The deoxygenated blood and waste are transported through veins. You have about 5 quarts of blood traveling continuously throughout your body. Blood is made up of plasma, a liquid, and the following three types of cells:

- Red cells, or erythrocytes, carry oxygen for delivery to all of your cells.
- White cells, or leukocytes, function as body police by fighting off bacteria and viruses.
- Platelets, or thrombocytes, are tiny pieces of cells that plug up injured blood vessels and start the clotting process when you get a cut.

Blood cells are created from the stem cells found in the red marrow of the skull, ribs, sternum, spine and pelvis. These stem cells divide and multiply to make various blood cells.

The primary organ of the circulatory system—the heart—pumps oxygenated blood out through the arteries to all parts of the body. Because the heart is a double pump with four chambers, it also pumps the deoxygenated blood to the lungs to be oxygenated again.

### Did you know?

Blood pressure is the amount of force with which blood pushes against the wall of an artery. If your blood pressure is high, your arteries can eventually become damaged. Serious health problems, such as blood clots or arterial blockages, are caused by high blood pressure. You can prevent these health problems by exercising and getting your blood pressure tested regularly.

Veins and arteries of the heart

# ACTIVITY Straight from the Heart

Students will define and demonstrate the functions of the heart, observe the pulsation of blood in the wrist, and construct a simple stethoscope.

## MATERIALS (per pair of students)

**Heart Model**

- one-half pear cut lengthwise
- two 6 inch pieces of surgical tubing
- 1 plastic spoon
- 1 small knife
- "heart" vocabulary per student

**Vibration Observation**

- small amount of modeling clay
- 1 match

**Stethoscope Model**

- one 3 feet piece of surgical tubing
- 2 funnels per model
- small amount of modeling clay

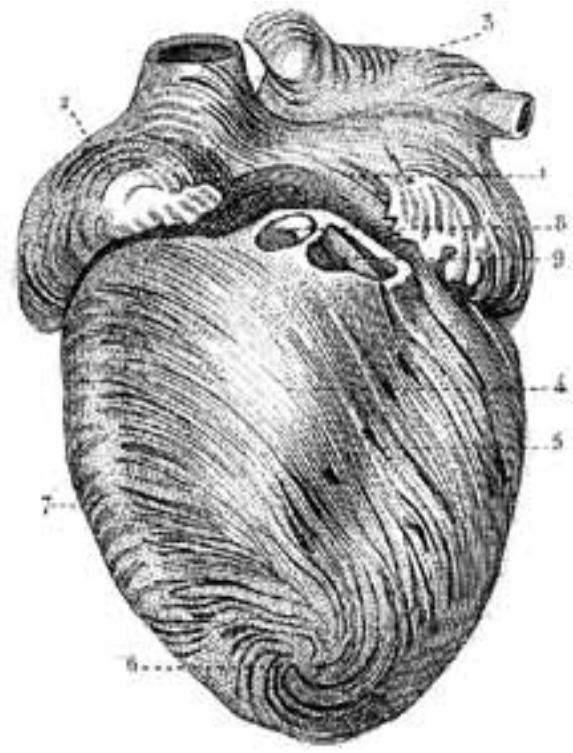
## PROCEDURE

**Heart Model**

1. Have students turn pear upside down and remove seeds.
2. Cut out two hollow openings at the top and two larger ones directly under them to represent the four chambers in the heart (left and right atrium, left and right ventricle).
3. Make a hole in the pear and insert surgical tubing to represent the largest artery of the heart (aorta) and the largest vein of the heart (superior vena cava).
4. Discuss functions of the aorta and superior vena cava.

**Vibration Observation**

1. Insert the match into a small piece of clay (the smaller the better).
2. Flatten the bottom of the clay.
3. Place your wrist, palm side up, on a table.
4. Place the clay on your wrist, and move the clay around on the thumb side of the wrist until the match starts to slowly vibrate back and forth.
5. Count the number of vibrations that the match makes in one minute.



# ACTIVITY Straight from the Heart

Students will define and demonstrate the functions of the heart, observe the pulsation of blood in the wrist, and construct a simple stethoscope.

**Stethoscope Model**

1. Cut the surgical tubing for the stethoscopes into approximately 3 feet lengths.
2. Slide the tubing over the end of each funnel. Use clay to hold the funnel in place.
3. Instruct students to be quiet because it will be hard to hear the sound of a heartbeat if there is a lot of background noise and talking.
4. Have one student place one end of the funnel on his ear while the second student places the other funnel near the left side of the chest.
5. Have students listen to the heartbeats of themselves and partners using stethoscopes and compare rates.
6. Calculate the number of times your heart beats in one hour.

## EXPLANATION

The normal resting heart rate for adults is between 60–80 beats per minute. The normal resting heart rate for children ranges from 80–140 beats per minute. As the heart contracts, blood is forced through the blood vessels. The blood moves at a rhythmic rate causing the blood vessels in the wrist to pulsate.

All blood vessels have this throbbing motion, but the vessels in the wrist are close to the surface of the skin and can be felt more easily. The funnel on the stethoscope gathers the sound made by the heart valves snapping shut with each heartbeat and passes those sound waves to your ear.

## EXTENSION

1. Have students compare results.
2. Discuss why some rates are lower than others. What factors could affect the heart rate?

# TEACHER'S GUIDE TO STUDENT LEARNING

### RESPIRATORY SYSTEM

You don't think about your breathing throughout the day, do you? You might, however, be more aware of your breathing after you finish exercising or running up stairs! Your lungs, the star of your respiratory system, allow you to take air in from your environment and extract the vital oxygen that is transported to all the cells in your body. Once finished with the air, your diaphragm, the muscle that works to inhale and exhale, expels carbon dioxide and other waste out into the environment.

Your lungs are made up of branches of tubes called bronchioles. Each bronchiole is about the same thickness as a hair. At the end of the bronchioles are microscopic air sacs known as alveoli. Alveoli take the oxygen molecules in the air and pass them to the red blood cells to deliver oxygen to the rest of the body.

Although it is up to your lungs to ventilate your body, it is up to *you* to keep harmful chemical fumes and cigarette smoke from damaging your lungs.

### Did you know?

Why we yawn is not completely understood. The most accepted explanation is that we yawn because oxygen levels in our lungs are low. But why do fetuses yawn when they do not even breathe? Why is yawning contagious? And why does it seem we yawn more when we are bored? These are just a few of the questions that remind us that there is still much to learn about how our bodies work.

Smoker's lungs

Healthy lungs

# ACTIVITY Do-It-Yourself Lung Model

Students will understand the anatomy and physiology of the human lung.

## INTRODUCING THE ACTIVITY

We breathe about 15 times a minute and are not even aware of it. A newborn breathes up to 70 times per minute. Breathing expels carbon dioxide, a toxic bi-product of cellular metabolism, and substitutes it with oxygen. Oxygen is necessary to conduct all the chemical reactions that allow us to get energy from food.

The respiratory system plays the main role in this important process and closely collaborates with the circulatory system to collect carbon dioxide from the body, bring it to the lungs and discharge it outside the body. In addition, the respiratory system distributes oxygen collected inside the lungs to the entire body. It also plays an important role in the process of speech, thanks to a series of specialized structures inside the pathways.

The activity below will provide students with a better understanding of lung anatomy and physiology.

## MATERIALS (per pair of students)

- 1 pair of scissors
- 6" of surgical tubing
- 3 good-sized balloons
- two rubber bands
- large lump of modeling clay
- 1 clear plastic one-liter bottle
- 1 three-way hose connector (available at the hardware store)

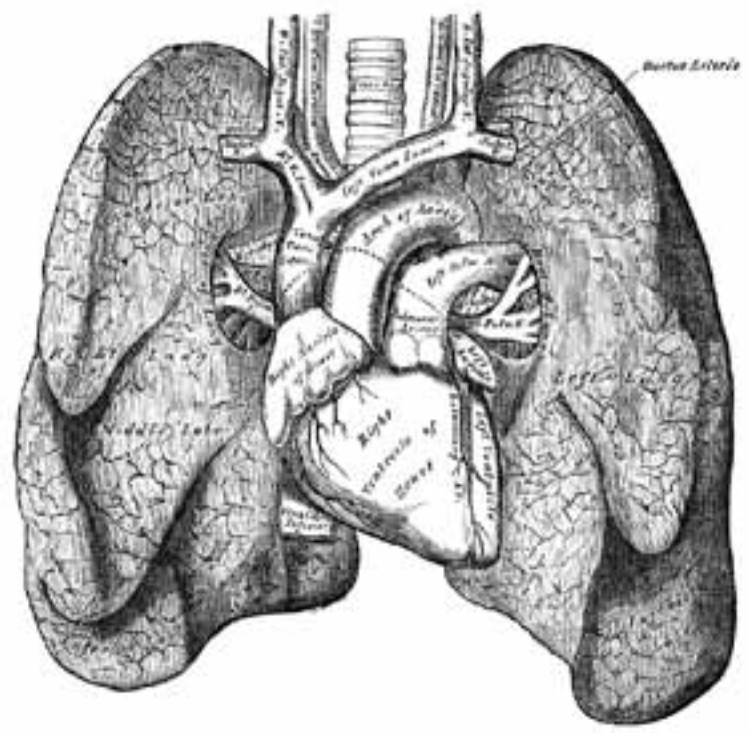
## PROCEDURE

**Assemble the "lungs"**

1. Push the plastic tube into one opening of the hose connector. Use the clay to make an airtight seal.
2. Tightly fix a balloon onto each of the other openings with the rubber bands, making sure the seal is airtight.

**Prepare the "chest cavity"**

1. Using scissors, carefully cut off the bottom 1 inch from the bottle making sure the cut edge is smooth.
2. Place the lungs (balloons and connector) inside and seal the plastic tube into the neck of the bottle with the rest of the clay to make an airtight fit.



# ACTIVITY Do-It-Yourself Lung Model

Students will understand the anatomy and physiology of the human lung.

**Prepare the "diaphragm"**

1. Tie a knot in the neck of the third balloon then carefully cut it in half, crossways.
2. Gently stretch the half of the balloon with the knot in it over the bottom of the bottle, pulling it up around the sides. Stretch the balloon as tight as you can, like the top of a drum.

**Start Breathing!**

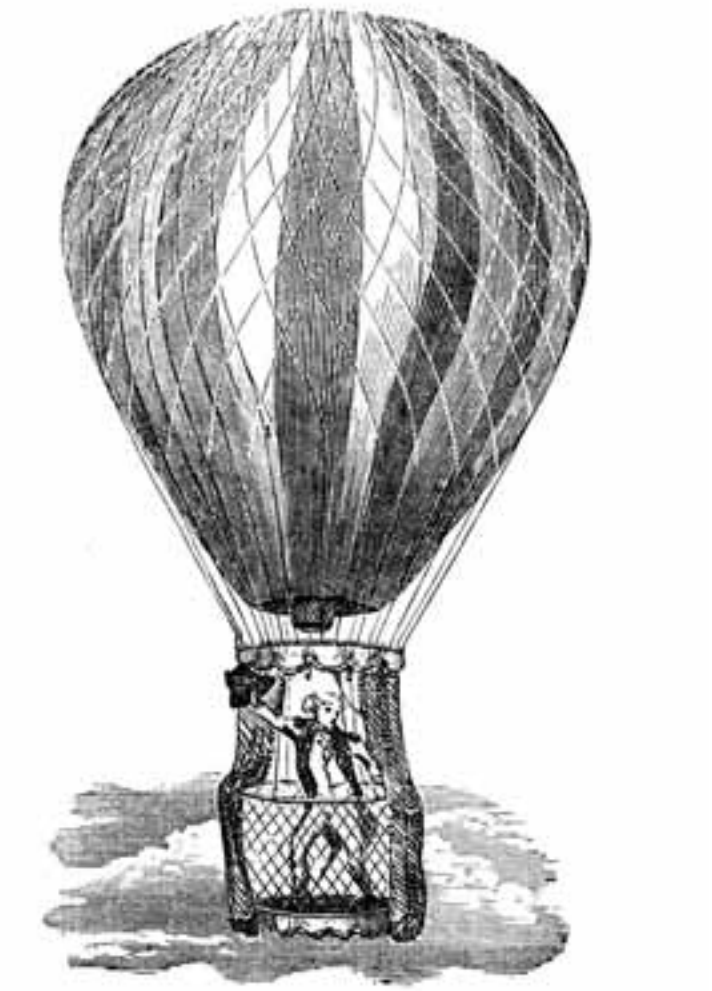
1. The lower part of the balloon represents the diaphragm, the main breathing muscle. Pull it down, as though you were inhaling.

## EXPLANATION

By pulling the lower part of the balloon down, the air pressure is lowered in the bottle. Air from outside rushes in and makes the two balloons expand just like the real lungs inside your chest.

## EXTENSION

1. Have students chart results
2. Discuss observations about when they pull the balloon down to represent inhalation.



# TEACHER'S GUIDE TO STUDENT LEARNING

### DIGESTIVE SYSTEM

We base our decision on what to eat largely on taste preferences and nutritional habits. Let's follow what happens to our food from the minute we put it into our mouth to the time it comes out the other end.

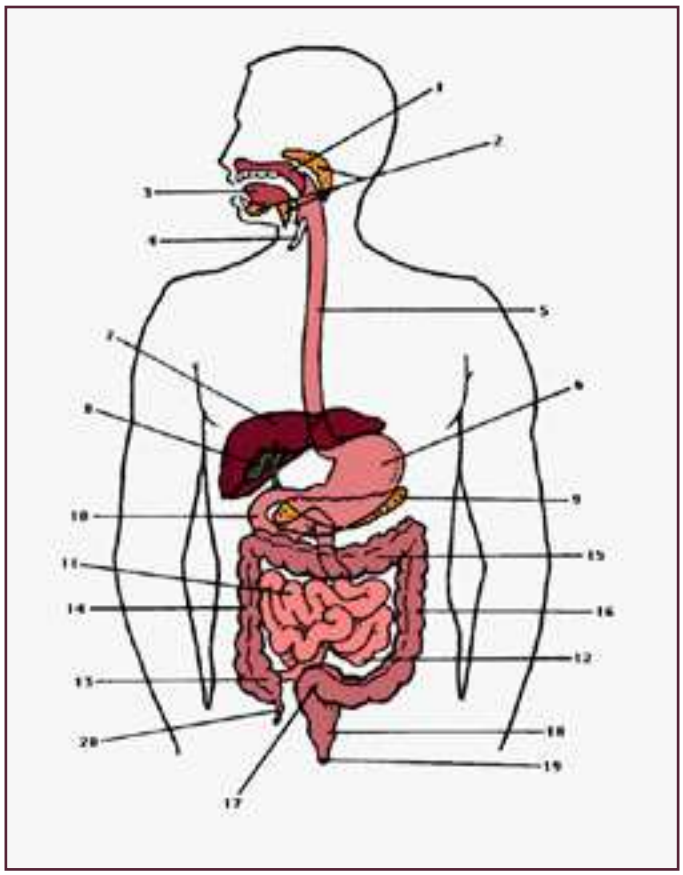
1. You put food into your mouth. Teeth prepare the food by chewing larger pieces into smaller, easier to swallow ones. Enzymes are added to get a start on breaking down foods chemically.
2. Once your food is chewed, it is pushed into the esophagus and squeezed down using a muscular action called peristalsis.
3. Food arriving in the stomach is subjected to highly acidic gastric juices that digest food and kill bacteria. Although the stomach churns and mixes the food, the stomach also acts as a storage compartment slowly changing the food into a gray, oatmeal-like mush known as chyme and passing it into the small intestine.
4. As the chyme enters the small intestine, it is mixed with green bile and other digestive juices to help with the absorption of minerals, vitamins, carbohydrates, proteins, and fats. This 26-foot long tube absorbs most of the nutrition from the food we eat.
5. Once the chyme makes it through the small intestine, its nutrients have already been stripped and transported to other organs. The fluid remains of the food have their water absorbed by the large intestine.
6. The final step. The nutrient and water remains of the food are stored in the rectum until there is enough to be defecated as feces.

## Did you know?

Your appendix, if you still have one, is a vestigial or undeveloped wormlike organ that has no known function. Sometimes, chyme accidentally finds its way into the appendix and it becomes infected or inflamed, causing appendicitis. An appendectomy is the surgical procedure used to remove the infected appendix before it bursts, a life-threatening emergency.

# TEACHER'S GUIDE TO STUDENT LEARNING

**Digestion:** 1 palate, 2 salivary glands, 3 tongue, 4 epiglottis, 5 esophagus, 6 stomach, 7 liver, 8 gallbladder, 9 pancreas, 10 duodenum, 11 jejunum, 12 ileum (10, 11, and 12 comprise the small intestine), 13 cecum, 14 ascending colon, 15 transverse colon, 16 descending colon, 17 sigmoid flexure, 18 rectum (13–18 comprise the large intestine), 19 anus, 20 vermiform appendix



**Did you know?**

A diet rich in fiber helps digested food move easier though the intestines. Although plant fiber does not provide us nutrition it is important to our digestion and helps to control overeating.

# ACTIVITY Experiments with Fats

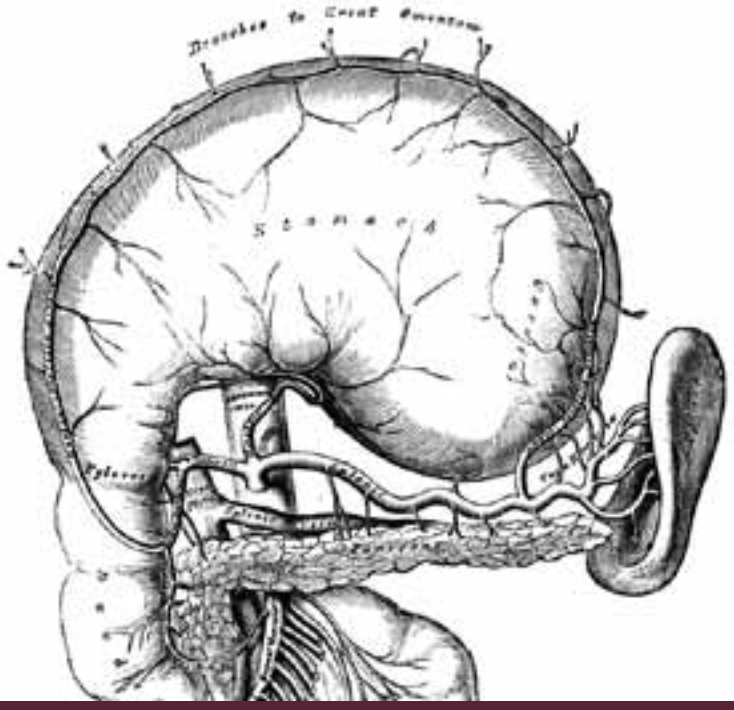
Students will learn how bile fluid in the intestines emulsifies oils and fats.

## INTRODUCING THE ACTIVITY

Explain to students that it is necessary for the body to emulsify fats to separate them and expose them to more enzymes. In this exercise, the dishwashing liquid represents the bile fluid.

Our digestive system works to break down food into fats, proteins, and starch molecules that can then be absorbed by our body. Once absorbed, these molecules must be transported via the blood stream to all parts of the body where they serve as fuel.

Food is broken down using the following two methods: (1) hydrolytic, which takes place in the presence of water and (2) enzymatic, where food is broken down using enzymes. These two processes, along with the physical actions of chewing, stomach churning, absorption by the microvilli in the intestine and transportation of nutrients via the bloodstream, make up the digestive system.



## MATERIALS (per group of students)

- 2 clear plastic cups
- warm water
- dishwashing liquid
- cooking oil
- 1 tablespoon
- 1 teaspoon

## PROCEDURE

1. Fill two glasses with warm water.
2. Add a tablespoon of cooking oil to each glass.
3. Add a teaspoon of dishwashing liquid to one of the glasses.
4. Stir the contents of both glasses really well.
5. Record observations.

## EXPLANATION

The glass with the dishwashing liquid will have a milky look to it. It should have tiny oil droplets. The other cup will have two very separate layers—one oil layer on the top and one water layer below.

The oil droplet will be very large in the glass without dishwashing liquid. The oil droplets in the glass with the dishwashing liquid will be smaller.

## EXTENSION

1. Have students compare the fat content of foods from different fast food restaurants.
2. Which has the highest percentage of fat content? Which has the lowest?

# TEACHER'S GUIDE TO STUDENT LEARNING

### URINARY SYSTEM

The chore of taking out the trash is a dirty job, but someone has to do it. Luckily, we have the urinary system dedicated to removing discarded waste from every cell and system of your body. Although defecation releases feces as the final step of digestion, only our body's urinary system "cleans up" after metabolic or chemical processes in the form of urine.

Urea, the body's main waste product excreted by cells into the bloodstream, has to be removed because it is toxic. Traveling through the bloodstream, urea is filtered out from the blood by the kidneys. Your kidneys, located just below the ribs in the lower back, produce urine by combining the urea with other metabolic waste, salts, ions, and excess water.

The urine is transported via tube-like ureters to the bladder acting like a storage tank. When enough urine has filled the bladder, the brain sends an impulse telling the sphincter to relax (open) and the detrusor muscle to contract allowing the urine to flow from the bladder and down the urethra in the process known as micturition or urination.

### Did you know?

Our kidneys filter about 48 gallons of blood per day or almost four 2-liter soda bottles an hour. Even after so much blood is filtered, we only produce about two liters of urine a day.

Veins and arteries of the kidney

# ACTIVITY Kidney Capers

Students will identify the structures and functions of the urinary system by building a model containing the kidney, ureters, bladder and blood vessels.

## INTRODUCING THE ACTIVITY

The urinary system includes the kidneys, bladder, ureter and blood vessels. These organs control the amount of water and salts that are absorbed back into the blood and what is taken out as waste. The urinary system also acts as a filtering mechanism for the blood.

## MATERIALS (per student)

- one large marshmallow = the bladder
- glue
- three kidney beans = the kidneys
- 2 drinking straws = the urethra
- 1 pair of scissors
- 3 spaghetti pieces = the ureters
- 2 pieces of red yarn = the arteries
- 2 pieces of blue yarn = represents the veins
- 1 sheet of construction paper (8 ½" x 11")

## PROCEDURE

1. Glue the kidney beans two inches from the top of the construction paper. Glue the beans side by side with three inches between them.
2. Glue both pieces of the red and blue yarn to the middle of the kidney beans to represent the arteries and veins bringing blood to and from the kidneys.
3. Insert two spaghetti pieces (ureters) into the large marshmallow (bladder). This demonstrates the ureters draining down into the bladder.
4. Insert the piece of straw (urethra) into the bottom of the large marshmallow (bladder). This represents the connection of the urethra to the bladder.
5. You now have a wonderful model of the urinary system!

## EXPLANATION

The two adult kidneys weigh, on average, 5.29–5.64 ounces. They are slightly different is size. The left kidney is generally bigger than the right kidney. However, both of them have a smooth surface. In fact, the lobe shaped kidney of a fetus tends to disappear during the first years of one's life.

## EXTENSION

1. Research renal calculi and the various methods for removing them from the body.

# NATIONAL STANDARDS CORRELATIONS

## NATIONAL STANDARDS FOR PHYSICAL EDUCATION

**Standard 2:** Demonstrates understanding of movement concepts, principles, strategies, and tactics as they apply to the learning and performance of physical activities.

**Standard 6:** Values physical activity for health, enjoyment, challenge, self-expression, and/or social interaction.

## NATIONAL HEALTH EDUCATION STANDARDS

**Standard 1:** Students will comprehend concepts related to health promotion and disease prevention to enhance health.

- 1.2.1: Identify that healthy behaviors affects personal health.
- 1.5.1: Describe the relationship between healthy behaviors and personal health.
- 1.8.1: Analyze the relationship between healthy behaviors and personal health.
- 1.8.7: Describe the benefits of and barriers to practicing healthy behaviors.
- 1.12.1: Predict how healthy behaviors can affect health status.
- 1.12.7: Compare and contrast the benefits of and barriers to practicing a variety of healthy behaviors.

**Standard 2:** Students will analyze the influence of family, peers, culture, media, technology, and other factors on health behavior.

- 2.5.6: Describe ways that technology can influence personal health.
- 2.8.6: Analyze the influence of technology on personal and family health.
- 2.12.6: Evaluate the impact of technology on personal, family, and community health.

**Standard 3:** Students will demonstrate the ability to access valid information and products and services to enhance health.

- 3.5.2: Locate resources from home, school, and community that provide valid health information.
- 3.8.2: Access valid health information from home, school, and community.
- 3.12.2: Use resources from home, school, and community that provide valid health information.

**Standard 5:** Students will demonstrate the ability to use decision-making skills to enhance health.

- 5.5.4: Predict the potential outcomes of each option when making a health-related decision.
- 5.8.5: Predict the potential short-term impact of each alternative on self and others.
- 5.12.5: Predict the potential short- and long-term impact of each alternative on self and others.

**Standard 6:** Students will demonstrate the ability to use goal-setting skills to enhance health.

- 6.8.1: Assess personal health practices.
- 6.12.1: Assess personal health practices and overall health status.

**Standard 7:** Students will demonstrate the ability to practice health-enhancing behaviors and avoid or reduce health risks.

- 7.5.1: Identify responsible personal health behaviors.
- 7.8.1: Explain the importance of assuming responsibility for personal health behaviors.
- 7.12.1: Analyze the role of individual responsibility in enhancing health.

## NATIONAL SCIENCE EDUCATION STANDARD K–4

### Content Standard A: Science as Inquiry

- Abilities necessary to do scientific inquiry
  - Plan and conduct a simple investigation
  - Employ simple equipment and tools to gather data and extend the senses
  - Use data to construct a reasonable explanation
  - Communicate investigations and explanations

# NATIONAL STANDARDS CORRELATIONS

## NATIONAL SCIENCE EDUCATION STANDARD
K–4

### Content Standard B: Physical Science

- Properties of objects and materials
  - Objects have many observable properties, including size, weight, shape, color, temperature, and the ability to react with other substances. Those properties can be measured using tools, such as rulers, balances, and thermometers

### Content Standard C: Life Science

- The characteristics of organisms
  - Each plant or animal has different structures that serve different functions in growth, survival, and reproduction. For example, humans have distinct body structures for walking, holding, seeing, and talking.
  - The behavior of individual organisms is influenced by internal cues (such as hunger) and by external cues (such as a change in the environment). Humans and other organisms have senses that help them detect internal and external cues.
- Life cycles of organisms
  - Plants and animals have life cycles that include being born, developing into adults, reproducing, and eventually dying. The details of this life cycle are different for different organisms.

### Content Standard E: Science and Technology

- Understanding about science and technology
  - Tools help scientists make better observations, measurements, and equipment for investigations. They help scientists see, measure, and do things that they could not otherwise see, measure and do.

### Content Standard F: Science in Personal and Social Perspectives

- Personal health
  - Individuals have some responsibility for their own health. Students should engage in personal care—dental hygiene, cleanliness, and exercise—that will maintain and improve health. Understandings include how communicable diseases, such as colds, are transmitted and some of the body's defense mechanisms that prevent or overcome illness.
  - Nutrition is essential to health. Students should understand how the body uses food and how various foods contribute to health. Recommendations for good nutrition include eating a variety of foods, eating less sugar, and eating less fat.
  - Different substances can damage the body and how it functions. Such substances include tobacco, alcohol, over-the-counter medicines, and illicit drugs. Students should understand that some substances, such as prescription drugs, can be beneficial, but that any substance can be harmful if used inappropriately.

### Content Standard G: History and Nature of Science

- Science as a human endeavor
  - Although men and women using scientific inquiry have learned much about the objects, events, and phenomena in nature, much more remains to be understood. Science will never be finished.

# NATIONAL STANDARDS CORRELATIONS

## NATIONAL SCIENCE EDUCATION STANDARD 5–8

### Content Standard A: Science as Inquiry

- Abilities necessary to do scientific inquiry
  - Design and conduct a scientific investigation
  - Use appropriate tools and techniques to gather, analyze, and interpret data
  - Develop descriptions, explanations, predictions, and models using evidence
  - Think critically and logically to make the relationships between evidence and explanations
  - Communicate scientific procedures and explanations
  - Use mathematics in all aspects of scientific inquiry

### Content Standard C: Life Science

- Structure and function in living systems
  - Living systems at all levels of organization demonstrate the complementary nature of structure and function. Important levels of organization for structure and function include cells, organs, tissues, organ systems, whole organisms, and ecosystems.
  - Specialized cells perform specialized functions in multi-cellular organisms. Groups of specialized cells cooperate to form a tissue, such as a muscle. Different tissues are in turn grouped together to form larger functional units, called organs. Each type of cell, tissue, and organ has a distinct structure and set of functions that serve the organism as a whole.
  - The human organism has systems for digestion, respiration, reproduction, circulation, excretion, movement, control, and coordination, and for protection from disease. These systems interact with one another.
- Reproduction and heredity
  - In many species, including humans, females produce eggs and males produce sperm...An egg and sperm unite to begin development of a new individual. That new individual receives genetic information from its mother (via the egg) and its father (via the sperm). Sexually produced offspring never are identical to either of their parents.
- Regulation and behavior
  - Regulation of an organism's internal environment involves sensing the internal environment and changing physiological activities to keep conditions within the range required to survive.

### Content Standard E: Science and Technology

- Understandings about science and technology
  - Perfectly designed solutions do not exist. All technological solutions have trade-offs, such as safety, cost, efficiency, and appearance.

### Content Standard F: Science in Personal and Social Perspectives

- Personal health
  - Regular exercise is important to the maintenance and improvement of health. The benefits of physical fitness include maintaining healthy weight, having energy and strength for routine activities, good muscle tone, bone strength, strong heart/lung systems, and improved mental health. Personal exercise, especially developing cardiovascular endurance, is the foundation of physical fitness.
  - The use of tobacco increases the risk of illness. Students should understand the influence of short-term social and psychological factors that lead to tobacco use, and the possible long-term detrimental effects of smoking and chewing tobacco.
  - Alcohol and other drugs are often abused substances. Such drugs change how the body functions and can lead to addiction.
  - Food provides energy and nutrients for growth and development. Nutrition requirements vary with body weight, age, sex, activity, and body functioning.

# NATIONAL STANDARDS CORRELATIONS

## NATIONAL SCIENCE EDUCATION STANDARD

### 5–8

#### Content Standard F: Science in Personal and Social Perspectives *(continued)*

- Science and technology in society
  - Technology influences society through its products and processes. Technological changes are often accompanied by social, political, and economic changes that can be beneficial or detrimental to individuals and society. Social needs, attitudes, and values influence the direction of technological development.
  - Science cannot answer all questions and technology cannot solve all human problems or meet all human needs. Students should understand the difference between scientific and other questions. They should appreciate what science and technology can reasonably contribute to society and what they cannot do. For example, new technologies often will decrease some risks and increase others.

#### Content Standard G: History and Nature of Science

- History of science
  - Many individuals have contributed to the traditions of science. Studying some of these individuals provides further understanding of scientific inquiry, science as a human endeavor, the nature of science, and the relationships between science and society.
  - Tracing the history of science can show how difficult it was for scientific innovators to break through the accepted ideas of their time to reach the conclusions that we currently take for granted.

### 9–12

#### Content Standard A: Science as Inquiry

- Abilities necessary to do scientific inquiry
  - Design and conduct scientific investigations
  - Use technology and mathematics to improve investigations and communications
  - Communicate and defend a scientific argument
- Understandings about scientific inquiry
  - Scientists usually inquire about how physical, living, or designed systems function. Conceptual principles and knowledge guide scientific inquiries. Historical and current scientific knowledge influence the design and interpretation of investigations and the evaluation of proposed explanations made by other scientists.
  - Scientists rely on technology to enhance the gathering and manipulation of data. New techniques and tools provide new evidence to guide inquiry and new methods to gather data, thereby contributing to the advance of science. The accuracy and precision of the data, and therefore the quality of the exploration, depends on the technology used.
  - Mathematics is essential in scientific inquiry. Mathematical tools and models guide and improve the posing of questions, gathering data, constructing explanations and communicating results.

# NATIONAL STANDARDS CORRELATIONS

## NATIONAL SCIENCE EDUCATION STANDARD 9–12

### Content Standard C: Life Science

- The cell
  - Cells can differentiate, and complex multicellular organisms are formed as a highly organized arrangement of differentiated cells. In the development of these multicellular organisms, the progeny from a single cell form an embryo in which the cells multiply and differentiate to form the many specialized cells, tissues and organs that comprise the final organism. This differentiation is regulated through the expression of different genes.
- Molecular basis of heredity
  - Most of the cells in a human contain two copies of each of 22 different chromosomes. In addition, there is a pair of chromosomes that determines sex: a female contains two X chromosomes and a male contains one X and one Y chromosome. Transmission of genetic information to offspring occurs through egg and sperm cells that contain only one representative from each chromosome pair. An egg and a sperm unite to form a new individual. The fact that the human body is formed from cells that contain two copies of each chromosome, and therefore two copies of each gene, explains many features of human heredity, such as how variations that are hidden in one generation can be expressed in the next.
- Matter, energy, and organization in living systems
  - The complexity and organization of organisms accommodates the need for obtaining, transforming, transporting, releasing, and eliminating the matter and energy used to sustain the organism.
- Behavior of organisms
  - Multicellular animals have nervous systems that generate behavior. Nervous systems are formed from specialized cells that conduct signals rapidly through the long cell extensions that make up nerves. The nerve cells communicate with each other by secreting specific excitatory and inhibitory molecules. In sense organs, specialized cells detect light, sound, and specific chemicals and enable animals to monitor what is going on in the world around them.

### Content Standard E: Science and Technology

- Understandings about science and technology
  - Science often advances with the introduction of new technologies. Solving technological problems often results in new scientific knowledge. New technologies often extend the current levels of scientific understanding and introduce new areas of research.

### Content Standard F: Science in Personal and Social Perspectives

- Personal and community health
  - Hazards and the potential for accidents exist. Regardless of the environment, the possibility of injury, illness, disability, or death may be present. Humans have a variety of mechanisms—sensory, motor, emotional, social, and technological—that can reduce and modify hazards.
  - The severity of disease symptoms is dependent on many factors, such as human resistance and the virulence of the disease-producing organism. Many diseases can be prevented, controlled, or cured. Some diseases, such as cancer, result from specific body dysfunctions and cannot be transmitted.
  - Personal choice concerning fitness and health involves multiple factors. Personal goals, peer and social pressures, ethnic and religious beliefs, and understanding of biological consequences can all influence decisions about health practices.

# NATIONAL STANDARDS CORRELATIONS

## NATIONAL SCIENCE EDUCATION STANDARD 9–12

### Content Standard F: Science in Personal and Social Perspectives *(continued)*

– An individual's mood and behavior may be modified by substances. The modification may be beneficial or detrimental depending on the motives, type of substance, duration of use, pattern of use, level of influence, and short- and long-term effects. Students should understand that drugs can result in physical dependence and can increase the risk of injury, accidents, and death.

– Selection of foods and eating patterns determine nutritional balance. Nutritional balance has a direct effect on growth and development and personal well-being. Personal and social factors—such as habits, family income, ethnic heritage, body size, advertising, and peer pressure—influence nutritional choices.

### Content Standard G: History and Nature of Science

• Historical perspectives

– In history, diverse cultures have contributed scientific knowledge and technologic inventions. Modern science began to evolve rapidly in Europe several hundred years ago. During the past two centuries, it has contributed significantly to the industrialization of Western and non- Western cultures. However, other, non-European cultures have developed scientific ideas and solved human problems through technology.

– Occasionally, there are advances in science and technology that have important and long-lasting effects on science and society.

– The historical perspective of scientific explanations demonstrates how scientific knowledge changes by evolving over time, almost always building on earlier knowledge.

### Psychology

• IIA–2.1.A, IIA–2.1.B, IIA–2.1.C, IIA–2.2.A, IIA–2.2.B, IIA–3.1.A, IIA–3.1.B, IIA–3.2.A, IIA–3.3.A, IIA–4.1.B, IIA–5.1.B

# GRANT RESOURCES

## National Funding Programs:

| | |
|---|---|
| **Gear Up! US Dept of Education** | www2.ed.gov/programs/gearup/index.html |
| **SchoolGrants** | www.k12grants.org |
| **Edutopia** | www.edutopia.org |
| **U.S. Department of Education** | www2.ed.gov/fund/landing.jhtml |
| **Grants Alert** | www.grantsalert.com |
| **Foundation Center** | www.foundationcenter.org |
| **The RGK Foundation** | www.rgkfoundation.org |
| **National Science Foundation** | www.nsf.gov/funding |
| **Donors Choose** | www.donorschoose.org |
| **National Education Association** | www.nea.org/grants |
| **The School Funding Center** | www.schoolfundingcenter.info |
| **American Federation of Teachers, Tools for Teachers** | www.aft.org/tools4teachers/funding.htm |
| **Science Education Partnership Award (SEPA) Program** | www.ncrrsepa.org/map/ed_state_list.jsp |
| **eSchool News** | www.eschoolnews.com/funding |
| **Rural Assistance Center** | www.raconline.org |

## Corporate Grant Programs and Resources

| | |
|---|---|
| **Target Field Trip Grants** | targetfieldtripgrants.target.com |
| **Corning Foundation** | www.corning.com/about_us/corporate_citizenship/community.aspx |
| **Toyota USA Foundation** | www.toyota.com/about/philanthropy/education |
| **Toshiba America Foundation** | www.taf.toshiba.com |
| **Verizon Foundation** | www.verizonfoundation.org/grant/index.shtml |
| **JCPenney** | www.jcpenney.net/about/social_resp/community/default.aspx |
| **Macy's Foundation** | www.macysinc.com/community/applicationprocess.aspx |
| **W.K. Kellogg Foundation** | www.wkkf.org/who-we-are/who-we-are.aspx |

# HISTORY OF ANATOMY

## BCE

**1600–1550:**
Two ancient **Egyptian papyri** distinguish organs such as the heart, liver, spleen, kidney, uterus, and bladder as well as blood vessels. No doubt the practice of mummification left the Egyptians intimately familiar with some aspects of human anatomy.

**c.500:**
The first recorded medical dissection of a human body is by the ancient Greek philosopher and medical theorist **Alcmaeon** of Croton who is credited with identifying the Eustachian tubes (auditory canals). He also classifies the brain as the seat of intellectual activity.

**c.400:**
**Hippocrates**, founds the Asclepiades, a school of medicine. He is the author of the medical oath of ethics and the earliest medical scientist who has a significant amount of extant work which exhibits an understanding of the musculoskeletal structure and human organs.

**c.384–322:**
The philosopher **Aristotle** distinguishes between arteries and veins. He relies on teaching anatomy through "paradigms, schemata and diagrams" as well as animal dissection rather than the use of human cadavers.

**c.280:**
During the Ptolemaic era, cadaver dissection is allowed at the anatomy school in Alexandria on the coast of northern Africa. **Herophilius** of Chalcedon, a Greek physician and early "Father of Anatomy," studies the nervous system, reproductive organs, and blood vessels. His work was complemented by **Erasistratus** of Chios, the leader of the school who revealed more about the cardiovascular system.

## CE

**30:**
The Roman physician **Aulus Cornelius Celsus** publishes *De re medicina*, or *On Medicine,* a collection of Greek medical writings featuring anatomy and surgeries.

**162:**
The Greek scientist **Galen** moves to Rome and becomes a physician at the imperial court. He gained valuable experience as the attending physician at a gladiator school and was known for his brain and eye surgeries. His works form the basis of medical knowledge through 13 centuries, due in large part to the ban on cadaver dissection in medieval Christendom.

**1489:**
**Leonardo da Vinci** begins creating a series of over 700 anatomical drawings. Although often relying on assumptions based on animal anatomy, da Vinci purportedly dissected dozens of cadavers to learn more about the inner workings of the human body.

**1522–1523:**
**Jacopo Berengario da Carpi** publishes *Isagogae breves per lucide ac uberrime in Anatomiam humani corporis,* the first detailed anatomic description of the human body in a series of illustrations.

**1543:**
**Andreas Vesalius'** *De humani corporis fabrica,* or *On the Workings of the Human Body,* features elaborate and accurate drawings of the dissected human body. This tome marks the beginning of modern anatomy and emphasizes the importance of dissection.

**1562:**
**Gabriele Fallopio** describes the anatomy of several reproductive organs, in particular the uterine tubes today commonly called the "Fallopian" tubes.

# HISTORY OF ANATOMY

## CE

**1628:**
**William Harvey** writes *Exercitatio anatomica de motu cordis et sanguinis in animalibus* or *The Anatomical Function of the Movement of the Heart and Blood in Animals* in which he correctly explains the circulatory system.

**1632:**
The painting ***Anatomy Lesson of Dr. Nicolaes Tulp***, by Rembrandt, demonstrates the intimate connection between artists and anatomists as well as the atmosphere of conviviality surrounding anatomy lessons in the 17th century.

**1661:**
The microscope begins to play a key role in the study of anatomy after **Marcello Malpighi**, the "Father of Microscopic Anatomy," uses it to discover capillaries.

**1664:**
**Thomas Willis** gives the first complete description of the anatomy of the brain.

**1718:**
The German surgeon **Lorenz Heister** publishes a treatise on surgery that becomes the standard text on the subject.

**1752:**
**Rene de Reaumur** shows the role of gastric juices in digestion.

**1771:**
The founder of pathologic anatomy, **Giovanni Battista Morgagni**, dies. He was known for his extensive and meticulous post-mortem examinations. In this same year, **William Hewson** details his research on blood coagulation.

**1774:**
London's leading obstetrician, **William Hunter**, publishes a definitive work on the reproductive system.

**1832:**
As the interest in anatomy grows, England passes the **Anatomy Act** to offer an adequate and legitimate supply of bodies and prevent body-snatching, grave-robbing, and murdering as means of providing anatomists with cadavers.

**1833:**
**Jan Evangelista Purkinje** discovers sweat glands. He would later discover the neurons in the cortex of the cerebellum and conducting fibers in the heart. He is also credited with the first system of classifying fingerprints and use of the word "protoplasm."

**1839:**
**Theodor Schwann** and **Matthias Jakob Schleiden** correctly articulate the cell theory, stating that the cell is the general unit of all life.

**1855:**
**Claude Bernard** describes what become known as hormones: special substances liberated by organs into the tissue fluids which assist in maintaining the constancy of the internal environment.

**1858:**
**Henry Gray**'s *Anatomy, Descriptive and Surgical* is first published. It soon becomes the foremost anatomical reference text and its descendant is still widely used today.

**1887:**
The **National Institutes of Health** is established in the USA.

# HISTORY OF ANATOMY

## CE

**1891:**
**Heinrich Wilhelm Gottfried von Waldeyer** proposes the neuron theory of the nervous system. He uses the term "neuron" to describe the nervous cells, or basic structural unit of the nervous system.

**1895:**
**Wilhelm Roentgen** demonstrates his new invention, the x-ray, on his wife's left hand at his lab in Wurzburg, Germany.

**1897:**
**Sir Charles Sherrington** coins the term "synapse" to describe functional contact between nerve cells.

**1921:**
**John Newport Langley** gives a detailed description of the structure and function of the autonomic nervous system.

**1952:**
**Felix Bloch** and **Edward Purcell** receive the Nobel Prize in Physics for their work on magnetic resonance phenomenon, leading to the development of Magnetic Resonance Imaging, or MRI.

**1953:**
**James Watson** and **Francis Crick** discover the molecular structure of DNA.

**1967:**
Although his patient would die less than three weeks after the procedure, South African surgeon **Christiaan Barnard**'s heart transplant procedure is considered the world's first successful one.

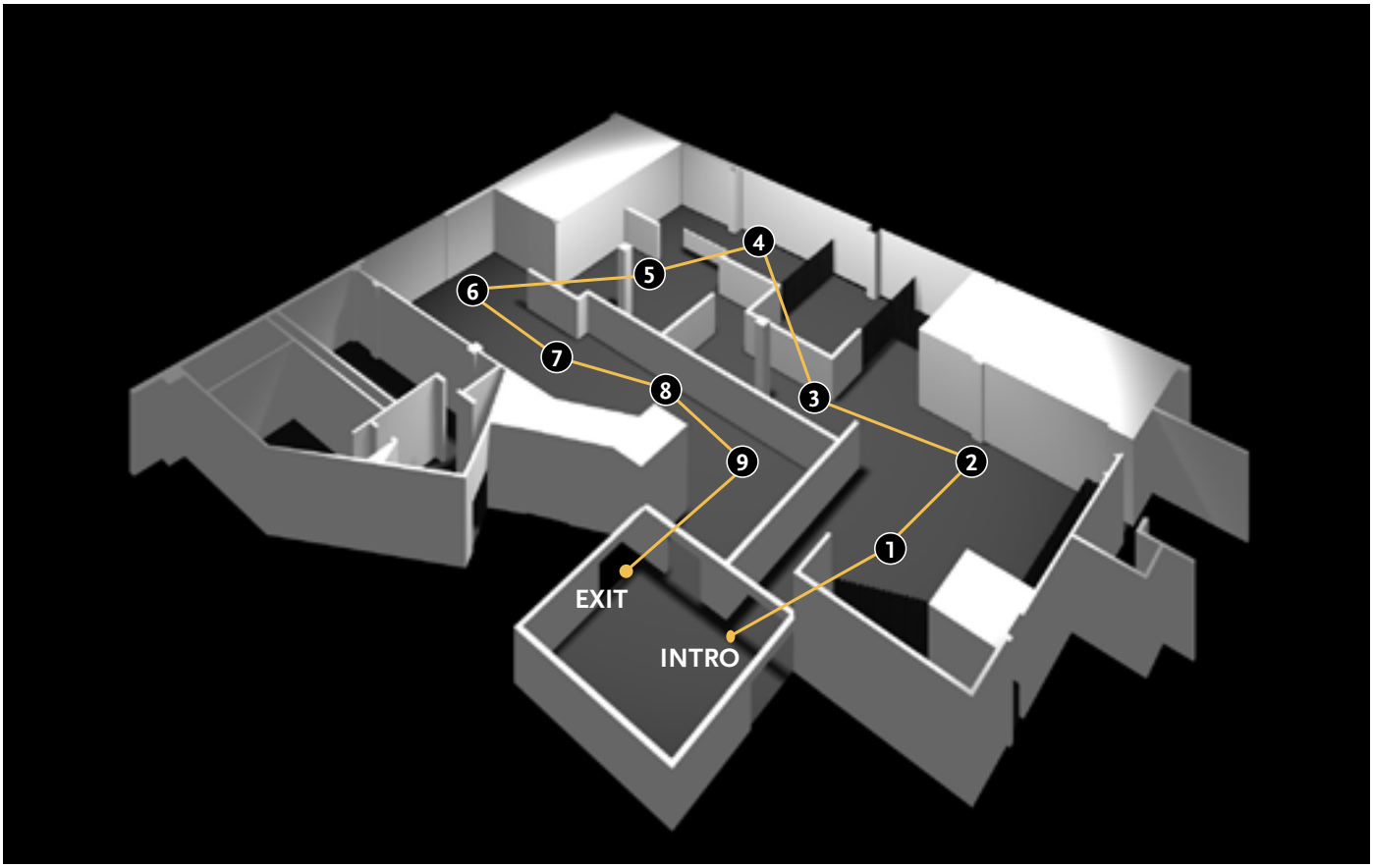
**1972:**
**Raymond Damadian** demonstrates an MRI of the whole body. In the same year, British engineer **Godfrey Hounsfield** and South African physicist **Allan Cormack** invent the technique known as Computer Assisted Tomography, or the CAT scan.

**1986:**
Work on the **Visible Human Project** begins with the goal of creating complete, anatomically detailed, 3-D representations of the normal male and female body.

**2003:**
The **Human Genome Project** is successful in identifying the approximately 20,000–25,000 genes in human DNA and in determining the sequences of the 3 billion chemical base pairs that comprise it.

# ORGANIZATION OF THE EXHIBITION

1. skeletal
2. muscular
3. nervous
4. fetal development *(optional)*
5. circulatory
6. respiratory
7. digestive
8. reproductive
9. treated body




The information in each Exhibition gallery is designed to provide answers to the following questions, among others:

**1. What are the systems of the human body?**

**2. How does each system of the body function?**

**3. How are the body's systems inter-related?**

**4. What can be done to improve and extend the life of the body?**

Students are encouraged to work with these questions before they arrive and to form some questions of their own. As a writing exercise, answers may be written in a journal prepared before your visit or upon return to your school.

# ORGANIZATION OF THE EXHIBITION

## Upon viewing the Exhibition, teachers and students will...

1. appreciate the sanctity and integrity of human life;
2. learn about the anatomy and complex systems of the human body;
3. learn how medical technology enhances one's quality of life;
4. become interested in their own body, how and why it works;
5. appreciate what it takes to care for the human body;
6. discover how daily choices affect the human body's health and well-being;
7. initiate conversations with friends and family about what it takes to sustain a healthy human body;
8. respect the human body in life and death;
9. understand that, regardless of how different we appear to be, the human body and its systems are much the same inside; and
10. explore careers in science, medicine and healthcare.

# TEACHER'S GUIDE TO EXHIBITION GALLERIES

This Exhibition uses full-body specimens to teach about the system or systems around which each gallery is designed. In addition, each gallery contains several cases featuring individual organs and sections of the body that relate to these systems. *Please note that all specimens on display are subject to change.*

There are 200 types of cells in the body; 75 trillion cells total.

Take time to view the projected images that appear on the walls of the galleries. These are artists' representations of cells and tissues, enlarged thousands of times!

**Femur**
The femur (thigh bone) is the longest bone in the body, articulating (joining) with the pelvis (hip), the tibia (shinbone), and the patella (kneecap). It is also the strongest bone in the body, capable of withstanding forces of up to 10 times body weight when running. Because of its length, measuring the femur in isolation is one the most accurate ways to determine a person's actual height.

**Head of Femur with Surgical Neck**
The rounded head of the femur contributes to the hip joint (a ball and socket joint). The femoral head is attached to the shaft of the femur by a narrow piece of bone. This portion of the femur is very susceptible to fractures, especially in elderly people. In fact when a person is said to have a broken hip, in most instances it is the surgical neck of the femur that is actually broken.

**Cross Section of Femur Head**
The ends of the long bones contain spongy bone tissue, which is visible in the cross-section of femur shown here. Spongy bone tissue makes bones lighter and distributes forces over a wider surface area. The outer layer and shafts of the long bones are made of compact bone tissue, which provides protection and support.

**Bones and Bone Tissues**
The bones of the human skeleton come in a variety of different shapes: long, short, flat, irregular, and sesamoid. All bones, regardless of their shape, are made up of spongy and compact bone tissue.

**The Whole Skeleton**

# TEACHER'S GUIDE TO EXHIBITION GALLERIES

## Skull

### Temporal Bone

The temporal bones form a part of the base of the skull. They are among the hardest of all bones, and enclose the tiny end organs of hearing and balance. The facial nerve, which is responsible for control of the facial muscles, winds though the temporal bone from the brain to the face.

### Maxillae

The paired upper jawbones (maxillae) hold the upper teeth. They also form the hard palate in the roof of the mouth, a portion of the floor of the orbit, and a part of the cheek. If the maxillae bones do not join properly during gestation, a cleft palate will result, leaving an opening between the mouth and nasal cavity, a condition that interferes with an infant's ability to nurse effectively.

### Bones of the Foot

The ankle is made up of seven tarsal bones while five metatarsal bones and fourteen phalanges form the skeleton of our feet and toes. All of these bones are joined together by strong ligaments. The soles of our feet do not lie flat on the ground but instead are arched. The shape of the foot arches are maintained primarily by the foot bones themselves.

These bones are shaped so that they can interlock and support their weight in an arch, much like the wedge-shaped blocks of an arched bridge can support the bridge without other mechanical supports. Foot arches help support the weight of the body and ensure that the blood vessels and nerves on the soles of our foot are not pinched when we are standing.

### Bones of the Hand

Each hand contains 26 bones. The looser association of bones and ligaments in the hand (when compared with those in the foot) allows for greater mobility and dexterity. Freeing the upper limb from the burden of weight bearing has enabled the human hand to develop delicate touch and dexterity. Due in part to the proportion of the bones in the hand, humans, like all primates, have an opposable thumb, the ability to touch the tip of the thumb with the tip of each finger.

### Bone Blood Supply

The centers of most adult long bones contain hollow spaces filled with yellow marrow. Yellow marrow is inactive and gets its name because it is made up predominantly of fatty tissue. Certain adult bones (i.e., the sternum, ribs, vertebrae, pelvis, etc.) contain red marrow and serve as active sites of red and white blood cell production.

Red marrow has been shown to create more than two million new red blood cells per second. Blood circulates into and out of the marrow via small openings, or foramina, in the bone, delivering nutrients to its bone forming tissue and carrying newly formed red and white blood cells into the circulation.

# TEACHER'S GUIDE TO EXHIBITION GALLERIES

### Expanded Skull

This internal view of the skull allows you to see the complex composition of the skull from the inside out. You can see the many bones that form the base of the skull and the several openings (foramina) that allow blood vessels and nerves to pass into and out of the cranial cavity.

The largest of these openings, the foramen magnum, is the point at which the spinal cord connects with the brain. Notice also the zygomatic (cheek) arches on either side of the skull; they provide the bony foundation for the cheeks and are points of attachment for some of the muscles of mastication and facial expression.

### Vertebral Column (without Sacrum)

The human vertebral column, or spine, typically consists of 24 vertebrae, which support and stabilize the upper body while forming a strong and flexible housing for the spinal cord. In addition, the spine has three natural curves that help it distribute weight and absorb shock.

### Cervical Segment of Vertebral Column

The seven cervical vertebrae are the least robust of the vertebral column, yet are strong enough to support the neck and allow for a wide range of motion. These vertebrae include the atlas and axis; the first two vertebrae of the spine, the atlas and axis allow the head to nod and rotate.

### Cervical Vertebra

The seven cervical vertebrae are the least robust of the vertebral column, yet are strong enough to support the neck and allow for a wide range of motion. These vertebrae include the atlas and axis; the first two vertebrae of the spine, the atlas and axis allow the head to nod and rotate.

### Thoracic Vertebra

The 12 thoracic vertebrae are slightly larger than the cervical vertebrae; each connects with one of the 12 pairs of ribs.

### Thoracic Segment of Vertebral Column

The 12 thoracic vertebrae are slightly larger than the cervical vertebrae; each connects with one of the 12 pairs of ribs.

### Bones of the Forearm with Interosseus Membrane

The two bones of the forearm, the ulna and the radius, extend from the elbow to the wrist. The forearm is the site of one of the most common fractures, known as a Colles' fracture, which usually occurs when someone falls and lands on their outstretched hands. Another joint formed just below the elbow, the radioulnar joint allows the palm of the hand to be turned upward (supination) and downward (pronation). The interosseus membrane of the forearm is a fibrous sheet that connects the radius and the ulna. It is the main part of the fibrous joint between the two bones.

# TEACHER'S GUIDE TO EXHIBITION GALLERIES

### Hip Joint
One of the strongest and most stable joints in the body, the hip joint forms where the ball at the head of the femur (thighbone) fits into the acetabulum (socket) of the hipbone. This joint structure allows for rotation as well as forward, backward, and side-to-side movement. Held in place by five ligaments and tough connective tissue deep in the joint, each hip joint often withstands 400 pounds of force in everyday activity.

### Elbow Joint
The elbow joint is formed by three bones: the lower (distal) end of the humerus (arm bone), and the upper (proximal) ends of both the ulna and the radius (bones of the forearm). The elbow joint is a hinge joint, allowing you to flex and extend your forearm. Because so many muscles originate or insert near the elbow, it is a common site for injury.

### Knee Joint
The knee is one of the most complex and least stable joints in the body. It is formed by three bones: the femur (thigh bone), the patella (kneecap), and the tibia (shin bone). Since its articular surfaces do not fit closely together, the knee relies mainly on ligaments and muscles for stability. This makes the knee joint very vulnerable to injury when excessive force is exerted upon it.

### Sagittal Section of Knee

### Shoulder Joint
The shoulder joint is formed by the articulation of three bones: the humerus (arm bone), the clavicle (collar bone), and the scapula (shoulder blade). Although it is strengthened by the tendons of four important muscles (the rotator cuff), the shoulder joint remains relatively unstable and is vulnerable to injury, such as dislocation by a sudden force or damage resulting from extreme movements or over-strenuous exercise.

### Shoulder Joint with Open Capsule
Like all moveable joints, the shoulder is a synovial joint, meaning its bones are contained within a capsule lined by a synovial membrane. This membrane secretes synovial fluid, a viscous fluid that allows for frictionless movement within the joint. Synovial fluid is so effective as a lubricant that scientists are trying to synthesize it for industrial use. If the joint capsule becomes inflamed through over-use, trauma, or possibly infection, bursitis, a very painful condition, may result.

### Bone Joints
Bones meet at joints. The various joints—hinge, ball and socket, swivel, gliding, and saddle—allow bones to move in different ways and are named for their shapes and the movement they allow.

### Bone, Cartilage, Deep Muscles + Joints
This dissection demonstrates the important relationship between the bones of our skeletons and the cartilage and muscle attached to these bones.

Perhaps more than any other example in the Exhibition, this specimen shows how you are held together and upright. What you see here is the skeleton, the framework of the body, and many of the muscles closest to it.

# TEACHER'S GUIDE TO EXHIBITION GALLERIES

### Muscle Attachments + Layering
Your skeleton moves when muscles contract and pull on your bones. This produces both highly coordinated movements, such as running, and relatively simple localized movements, such as brushing your teeth.

### Muscle Control / Muscle Names, Shapes + Knots
The dynamic pose of this specimen illustrates the body's agility and balance, achieved by many muscle groups working together and through precise control of the skeletal muscles.

Muscles are named for their shape, their location on the body, or for a combination of these factors.

### Joints of the Hand
There are three bones in each finger called phalanges, as well as three joints. The first joint is located where the finger meets the hand, while the other two separate the three phalanges. The thumb contains one of the most important joints in the body, the basal joint. It attaches the metacarpal bone to the trapezium bone of the wrist, and allows the thumb to touch all of the fingers, a motion called opposition-or what is known as an opposable thumb.

### Joints of the Foot
The bones of the foot and ankle make up a complex array of joints, allowing them to act as a lever to move us forward, to create arches that distribute weight, and keep us stable. On this specimen, the top portion of bone has been removed to illustrate the ankle's articular cartilages, cavities, and ligaments. Connected by small joints and ligaments, the seven tarsal (ankle) bones help form the arches of the foot and allow for complex motion within the ankle.

### Superficial Muscles of the Hand

### Muscles of the Foot
There are 20 muscles in the foot that give it its shape and expand and contract to impart movement, including the extensors (which point the toes upward) and the flexors (which point the toes downward). The sole of the foot contains long tendons and a number of small muscles that are bound in four layers. Unlike the thumb on the hand, the big toe is prevented from opposing the other toes, even though they can be used to grasp objects.

### Arteries of the Foot
The two main arteries that supply the foot are the dorsal pedis artery and the posterior tibial artery. They distribute oxygenated blood through smaller capillaries to the tissues of the feet. While gravity assists in the pulling of blood towards the feet, it does not aid in the return trip to the heart. Since the major foot arteries are the farthest from the heart, many circulatory problems will first display themselves in the feet. Symptoms of reduced blood-flow to this area include cramping in the calf and lower leg, cold feet, and thick or brittle toenails.

### Muscle Names and Shapes
Muscles are named for their shape or location on the body or for a combination of these factors.

### Deep Muscles of the Hand

# TEACHER'S GUIDE TO EXHIBITION GALLERIES

## Muscles of the Hand

It takes 19 muscles to move the hand and the wrist, but not all of these muscles are within the hand. Some of these muscles (the major finger flexors and extensors) are located in the forearm and are connected to fingers of the hand via long tendons. Because these tendons are so much stronger than the muscles to which they attach, they can be much smaller. This keeps the hand to a manageable size and allows for everything from a firm grasp to the lightest touch. If the muscles of our forearm extended all the way to our fingers, our hands would be much larger, akin to constantly wearing boxing gloves.

## Muscles of the Face and Neck

The muscles of the neck allow for four different types of head movement: rotation (side to side), lateral flexion (ear to shoulder), flexion (chin to sternum), and extension (looking up). The most common injury involving the muscles of the neck is whiplash.

Human facial muscles are among the most evolved of all mammals. With this complex set of muscles, we can express even the slightest emotion or feeling. The muscles of the face also give each of us our unique appearance.

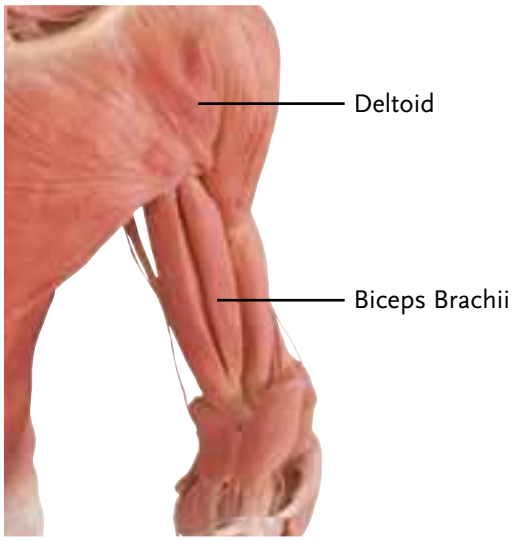
## Muscles of Upper Limb

The numerous muscles of the upper limb constantly work together to perform tasks like writing, lifting, or threading a needle. These muscles include:

**Deltoid**—Named for its triangular shape, delta in Greek, the deltoid muscle joins the upper arm to the shoulder. It helps lift the arm away from the side of the body and allows forward, backward, and side to side movement.

**Biceps Brachii**—The word "biceps" comes from the Latin words *bi*, meaning two, and *cephalon*, meaning head. The two heads of the biceps originate from two separate bones, the scapula (shoulder blade) and the humerus (arm). A single tendon inserts to the radius bone of the forearm.

**Supinator and Pronators**—These muscles are named for the actions they perform. Turn your palm upward-that is the supinator muscle working. Turn your palm down-these are the pronators at work. These muscles are called antagonists because they cause opposite motions.




## Sternoclavicular Joint

The sternal end of the clavicle and the manubrium of the sternum join together to create the sternoclavicular joint. This sternoclavicular joint, while technically a gliding joint, enjoys a wider than normal range of motion. An articular disc located within the joint capsule is thought to be responsible for this extra range of motion. The joint is supported by four powerful ligaments that also help to improve its flexibility.

## Latissimus Dorsi

Two large, wide muscles that run vertically along both sides of the back, the latissimus dorsi gives the back its distinctive "V" shape. The name latissimus dorsi comes from the Latin for "broadest (muscle) of the back." The muscle is particularly well developed in swimmers.

# TEACHER'S GUIDE TO EXHIBITION GALLERIES

### Muscles of Lower Limb

The muscles of the lower limb are the largest in the body and make us bipedal and mobile. They include:

**Gluteus Maximus**—he largest muscle in the body; it helps us keep our balance and move the thigh.

**Quadriceps Femoris**—This four-headed muscle makes up most of the muscle mass on the front and outside of the thigh and joins into the powerful quadriceps tendon just above the knee. This muscle is both a thigh flexor and a leg extensor and is important in actions such as kicking and running.

**Gastrocnemius**—One of two muscles that form the prominence of the calf, this large muscle connects to the Achilles tendon, the strongest tendon in the body, and helps us stand upright. The muscle is very prone to spasms-painful, involuntary contractions of the muscle that can last for several minutes. This condition is commonly known as a "Charley horse".

### Gluteus Maximus and Iliotibial Tract

The largest muscle in the body, the gluteus maximus helps us keep our balance and move the thigh. It inserts into the iliotibial tract, a superficial band of fascia (part of the connective tissue system) covering the thigh. The iliotibial tract helps maintain the structural integrity of the thigh, providing support and protection while also serving as a shock absorber.

### External Abdominal Oblique

The largest and most superficial (external) muscle of the abdominal wall, this flat, broad muscle gets a part of its name due to the fact that its muscle fibers run diagonally from the ribs to the midline of the body. The muscle supports the abdominal wall, assists forced expiration, and helps turn the trunk.

### Triceps Surae

The triceps surae is the name given to two muscles—the gastrocnemius and the soleus—that make up the prominent muscle mass of the calf. When the two muscles are considered together, they consist of three separate heads, thus the name triceps. The name surae comes from the Latin for "calf."

### Voluntary and Involuntary Muscles

Your body contains both voluntary and involuntary muscles, which are classified into three groups: voluntary (striated), cardiac (heart muscle), and smooth (involuntary).

Skeletal muscles are under willful control, while the cardiac and smooth muscles of the body are involuntary and work without any direction from you. Involuntary muscles are also known as smooth muscles because they have no striations like voluntary and cardiac muscles. Involuntary muscles perform vital functions in every body system, including respiratory, cardiovascular, and digestive. They are partly responsible for the amount of air that enters your lungs, for the rate at which your heart beats, and for the speed at which food travels though the digestive tract.

# TEACHER'S GUIDE TO EXHIBITION GALLERIES

The nervous system controls and integrates activities of the body. The central nervous system consists of the brain and spinal cord. The peripheral nervous system consists of the spinal nerves and the cranial nerves. Several peripheral (spinal) nerve networks, called plexi, originate from the spinal cord and branch out to eventually reach the skin and muscles of the upper and lower limbs.

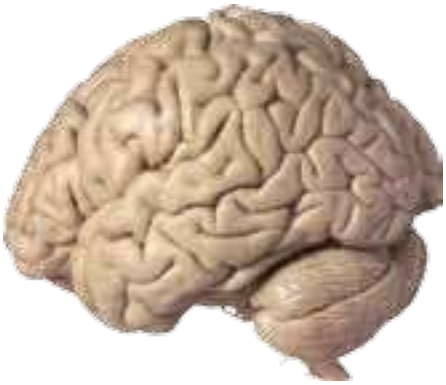
### Left Cerebral Hemisphere

### Dura Mater

The brain and spinal cord are surrounded by three membranes called meninges. These protect the central nervous system and provide the space throught which cerebrospinal fluid flows. The tough and fibrous outer layer, called the *dura mater* ("hard mother"), is visible here. It supports the brain and divides the cranial cavity into smaller compartments.

### Cerebellum

The cerebellum is the cauliflower-shaped organ at the base of the brain. Meaning "little brain" in Latin, the cerebellum controls equilibrium and coordinates our muscular movements. It is because of your cerebellum that you are able to stand on one foot, button your shirt, and walk smoothly through this Exhibition.



### The Brain

The brain is the mysterious organ of the central nervous system and is essential for all bodily functions. Weighing only 3 pounds (1.4 kilograms) in an average adult, it contains upwards of a trillion nerve cells, which are in constant communication with each other and the body. Some brain cells make connections with over 10,000 others in a split-second.

The brain continues to develop throughout life and can be subject to atrophy (weakening) in later years. Recent research has indicated that the brain is a "use it or lose it" organ, retaining its functional health and vitality as long as it is continually challenged and utilized.

### Hippocampus

The hippocampus is a deep midline fold of the cerebral hemisphere named after its resemblance to a sea horse (from the Greek *hippos* for horse and *kampus* for sea monster). The hippocampus is an important part of the limbic system and an essential site for the formation of short-term memory. It is one of the regions first affected by Alzheimer's disease.

### The Brain / The Brain + Spinal Cord

This specimen has a partially exposed brain, the main organ of the central nervous system, which controls everything we do: every thought, action, and emotion.

As the main conduit between the brain and the body, the spinal cord transmits millions of nerve impulses per second at speeds exceeding 270 miles per hour.

# TEACHER'S GUIDE TO EXHIBITION GALLERIES

### Arteries of the Ear

### Auditory Ossicles

Our skulls include the smallest bones in our bodies. Called auditory ossicles (little hearing bones), these bones are located within the temporal bones of the skull and have distinct shapes for which they are named. They are the malleus (hammer), the incus (anvil), and the stapes (stirrup). Connected by the smallest moveable joints in the body, these bones transfer sound as vibrations from the eardrum to the inner ear. This efficient structure allows us to hear even the faintest sounds.

### Eye with Extraocular Muscles, Nerves, and Vessels

In some ways, your eye is like a camera. Light reflected from an image passes through the pupil to the lens just behind it. The lens focuses that light on the retina, which, like film, is light sensitive. Here the light stimulus is converted to nerve impulses that are collected by the optic nerve and transmitted to visual centers located in the occipital lobes of the brain, where the pictures are developed. More than half of all the sensory receptors in our bodies are located in the retinas of our eyes, and a large part of the cerebral cortex is devoted to processing visual information.

The six tiny muscles that surround the eye and control its movements are known as the extraocular muscles (EOM). These six muscles move our eyes and align them with great precision.

### Ear Structure Showing Bony Labyrinth

The external ear funnels sound waves into the ear canal where they vibrate the eardrum. The eardrum then moves three tiny bones called auditory ossicles. These hearing bones have distinct shapes for which they are named—the malleus (hammer), the incus (anvil), and the stapes (stirrup). Connected by the smallest moveable joints in the body, these bones transfer sound as vibrations from the eardrum to the inner ear.

The inner ear contains sensory fibers within a region called the cochlea, which detects these vibrations and relays them to the brain, where they are interpreted as sound. The inner ear also contains the semicircular canals; three fluid-filled canals that help the body maintain balance.

### Eye with Extraocular Muscles, Nerves, and Vessels

In some ways, your eye is like a camera. Light reflected from an image passes through the pupil to the lens just behind it. The lens focuses that light on the retina, which, like film, is light sensitive. Here the light stimulus is converted to nerve impulses that are collected by the optic nerve and transmitted to visual centers located in the occipital lobes of the brain, where the pictures are developed. More than half of all the sensory receptors in our bodies are located in the retinas of our eyes, and a large part of the cerebral cortex is devoted to processing visual information.

The six tiny muscles that surround the eye and control its movements are known as the extraocular muscles (EOM). These six muscles move our eyes and align them with great precision.

### Section of Head Showing Eye Structure

# TEACHER'S GUIDE TO EXHIBITION GALLERIES

## Nerves of the Foot

The main nerve to the foot, the tibial nerve, originates in the spine and travels down the back of the leg to the bottom of the foot, where it branches out to the toes. This nerve innervates the toes and sole of the foot, while other nerves on the top of the foot innervate regions on the top and outside edge of the foot.

## Nerves of the Hand

Three large nerves supply the muscles and skin of the hand-the radial, median, and ulnar nerves. The radial nerve innervates the skin over most of the back of the hand and the back of the thumb. The median nerve innervates the skin of the palm, thumb, index, and middle fingers, as well as the adjacent side of the ring finger. The ulnar nerve innervates the little finger and the adjacent side of the ring finger and controls some movements of the hand.

The ulnar nerve passes near the surface of the humerus (arm bone) as it enters the forearm. When the nerve is knocked against the bone it results in a sharp tingly sensation. This is why the lower end of the humerus is commonly called the "funny bone".

## Display of 12 Cranial Nerves

The 12 pairs of cranial nerves provide innervation to the muscles and sensory structures of the head and neck, and also distribute nerves to the organs of the chest (thorax) and upper abdomen. These nerves include the:

**Olfactory Nerve**—Concerned with the sense of smell.

**Optic Nerve**—Carries visual impulses from the retina of the eye to the brain.

**Oculomotor, Trochlear, and Abducens Nerves**—These three nerves control muscle movements of the eyes, allowing for binocular vision.

**Trigeminal Nerve**—Supplies sensory fibers to the teeth and skin of the face; also supplies motor fibers to the muscles of mastication (chewing).

**Facial Nerve**—Supplies motor fibers to the muscles of facial expression; it also innervates taste buds on the front part of the tongue and the lacrimal (tear) glands.

**Vestibulocochlear Nerve**—Carries impulses for the sense of hearing and balance.

**Glossopharyngeal and Hypoglossal Nerves**—Responsible (in part) for the reflex regulation of breathing, heart rate, and blood pressure; for movements of the tongue; and the sensory innervation of the back of the tongue and soft palate.

**Vagus Nerve**—The longest of the cranial nerves, it is involved with functions such as speaking, coughing, sneezing, swallowing, secretions from glands of the stomach, and the sensation of hunger. The vagus nerve receives its name from the Latin for "to wander".

**Spinal Accessory Nerve**—Primarily responsible for the contraction of neck muscles that move of the upper shoulder and head.

# TEACHER'S GUIDE TO EXHIBITION GALLERIES

### Motor Units

Muscles are made up of motor units, which consist of all of the fibers within a muscle that are innervated by a single nerve fiber. The more powerful the muscle, the larger their motor units. In contrast, the finer and more precise the muscle is (such as the muscles that move the eyes), the smaller their motor units.

### Intraventricular Hemorrhage

Intraventriular hemorrhage (IVH) is bleeding inside or around the ventricles, the space in the brain containing cerebral spinal fluid. IVH is most common in premature babies, especially those of low birth weight. Nearly all IVH occurs within the first three days of life. Though its exact causes are unclear, bleeding can occur in a premature baby's brain because the blood vessels are very fragile and rupture easily. The smaller and more premature a baby is, the more likely it is that IVH will occur.

### Brain Section with Glioma

The nervous tissue is made up of two different types of cells: nerve cells, which conduct nerve impulses, and neuroglial cells, which support nerve cells. Neuroglia means "nerve glue." The name is appropriate because these cells are responsible for holding neurons in place.

In addition, neuroglial cells nourish the nerve cells and produce myelin, which insulates nerve fibers and aid in the conduction of nerve impulses. Despite all of their supporting roles, neuroglia are also the cells in the brain that can grow out of control and create very invasive brain tumors known as gliomas.

### Vertebral Column and Spinal Cord

The vertebral column (spine) is made up of approximately 33 individual bones (which are separated by discs) that give the spine its strength and flexibility. The vertebral column also has several curves, which correspond to the different regions of the column—the cervical, thoracic, lumbar, and pelvic regions. It also contains the vertebral canal, where the spinal cord is situated.

Usually just short of 18 inches long—it does not extend the full length of the vertebral column—the spinal cord has a series of nerve rootlets that attach to both the front (ventral rootlets) and back (dorsal rootlets) of the cord and form 31 pairs of spinal nerves.

# TEACHER'S GUIDE TO EXHIBITION GALLERIES

## Understanding the Brain

Even now, with all of our medical advancement, we have barely scratched the surface of understanding how the brain works. New techniques have helped us better understand the function of many parts of the brain, but the cause of diseases such as Parkinson's disease, multiple sclerosis, and amyotrophic lateral sclerosis (ALS/Lou Gehrig's disease) continue to be the focus of intense research and investigation.

Another area of intense research is central nervous system regeneration; unraveling the complexity of nerve cell growth might lead to better treatment for those affected by the paralysis that frequently results from spinal cord damage.

## Glioma with Hemmorrhage

The nervous system consists of two different types of cells: nerve cells, which conduct nerve impulses, and neuroglia, which support nerve cells. Neuroglia means "nerve glue". The name is appropriate because these cells are responsible for holding neurons in place. In addition, neuroglia cells help nourish nerve cells and produce myelin, which insulates their nerve fibers, thus aiding in the conduction of nerve impulses. Despite all of their supporting roles, neuroglia are also the cells in the brain that can grow out of control and create very invasive brain tumors known as gliomas.

## Stroke

The brain requires a massive and continual blood supply. If this blood supply is interrupted, even for one minute, brain tissues will begin to die. This is the case with stroke. It is caused by a blockage (ischemic stroke) or rupture (hemorrhagic stroke) in one or more of the brain's blood vessels. In the case of a rupture, a broken vessel fills part of the brain with blood, increasing pressure, and causing further tissue death. Those with high blood pressure and arteriosclerosis are at the greatest risk. Symptoms of stroke include paralysis, as well as language and vision impairment. The brain section in this case is an example of a large-scale and debilitating stroke.

# TEACHER'S GUIDE TO EXHIBITION GALLERIES

### Heart

The heart is a muscle that pumps blood to every part of the body. Each half consists of two chambers: an upper atrium and a lower ventricle. The atria are the chambers through which blood enters the ventricles. Once filled with blood the ventricles contract, forcing blood out of the heart. The more muscular left ventricle pumps blood to the far reaches of the body (systemic circulation); the less muscular right ventricle pumps blood a shorter distance to the lungs (pulmonary circulation).

### Heart Blood Supply

The beating heart, like other muscles, needs oxygen and other nutrients to provide energy for its work. The coronary arteries are the vessels that bring the blood to the heart muscle. Blockage of the coronary arteries result in the death of heart muscle, a condition that we commonly call a heart attack. Heart attacks are the number one cause of death in our society.

### Interior View of the Heart

The heart consists of four chambers: two upper chambers, called atria (from the Latin for entry hall), and two lower chambers, called ventricles (Latin for "little bellies"). The "thump-thump" sound you hear when listening to your heartbeat is not the sound of these chambers contracting—it is the sound of the heart's valves closing.

### Blood Vessels of the Heart

### Arteries of Upper Limb

### Arteries of Lower Limb

### Bronchial Tree and Intrapulmonary Arteries

### Blood Vessels of Duodenum, Pancreas, and Spleen

### Blood Vessels of Liver

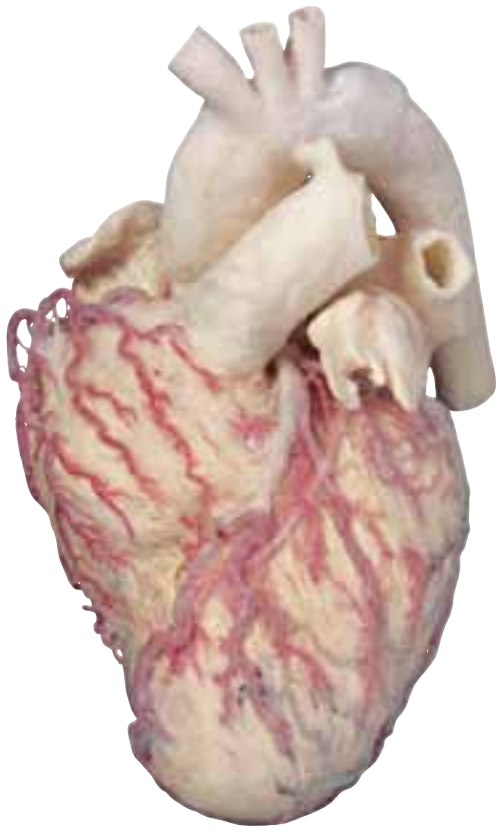
### Bronchial Tree and Vessels

### Duodenum, Pancreas, and Spleen

### Relationship of Heart and Lungs

### Blood Vessels of the Kidney

### Arteries of the Jejunum



# TEACHER'S GUIDE TO EXHIBITION GALLERIES

### Blood Vessels of the Body

A special dissection has revealed the blood vessels of this specimen, showing the vast surface area they cover and their proximity to every part of the body. The major arteries are visible, as are parts of the body where blood is most concentrated.

### Chronic Perisplenitis

Perisplenitis is the inflammation of the outer covering of the spleen.

### Enlarged Spleen

The spleen forms white blood cells that help protect the body from harmful pathogens. Because of that an enlarged spleen (megalosplenia) is most often a sign of an underlying problem such as infections, liver disease, and blood cancers. The most common cause of enlargement is malaria, a disease endemic to mosquito-infested tropical and sub-tropical areas, which affects the body's red blood cells. The Epstein-Barr virus, which causes mononucleosis, also leads to swelling of the spleen. If the spleen ruptures due to infection, it must be removed in emergency surgery. Removal of the spleen is not life threatening but it may lead to a weakened immune system.

### Transverse Section of Spleen

Every drop of blood in the body passes through the heart once each minute.

# TEACHER'S GUIDE TO EXHIBITION GALLERIES

### Tongue with Partial Pharynx and Larynx

### Throat and Bronchial Tree

This specimen displays the throat and lungs, which include:

**Larynx**—Located in the front of the throat, the larynx consists of the vocal cords and the epiglottis.

**Thyroid Cartilage**—Also known as the Adam's apple, it protects the front of the larynx and the vocal cords. Since men have longer and thicker vocal cords than women, their Adam's apples are larger.

**Trachea**—The pathway from the larynx to the bronchial tree, the trachea is kept open by 15 to 20 C-shaped cartilages instead of fluid or muscle, which would obstruct breathing.

### Alveoli

The bronchial tree ends in tiny air sacs called alveoli that look like clusters of grapes. Only one cell thick, the walls of the alveoli are in direct contact with the capillary walls of the pulmonary capillaries.

It is across this fragile membrane that life-supporting gas exchange occurs; here carbon dioxide diffuse from the bloodstream into the alveoli and is exhaled, while oxygen diffuses into the pulmonary bloodstream via which it circulates to every organ in the body. The lungs contain approximately 300 million of these alveoli that, if stretched out, would cover half a football field.

### Section of Heart

The average human heart beats approximately:

- 70 times per minute,
- 4,000 times per hour,
- 100,000 times per day,
- 36 million times per year, and 2.5 billion times over a 70-year life span.

The human body contains about six quarts of blood, which is circulated through the body three times every minute. In one day, your blood travels about 12,000 miles (20,000 kilometers).

The heart pumps more than one million barrels of blood over an average 70 year life-span—enough to fill three super tankers.

### Respiration + Circulation

This dissection displays many of the body's major arteries. In particular, it demonstrates the delicate interior architecture of the lungs.

### Section of Lung with Emphysema

Emphysema is a serious disease that results in the breakdown of elastic tissue within the lung. This eventually affects the alveoli in the lungs, leading to a breakdown of their walls, greatly enlarging them and reducing their number. The resulting decrease in surface area greatly impairs the lungs ability to exchange oxygen and carbon dioxide. As lung tissue continues to deteriorate, it begins to fill with fluid, leading to a near-permanent state of pneumonia—resulting in a chronic cough, loss of appetite, and fatigue. The most common cause of emphysema is cigarette smoking.

# TEACHER'S GUIDE TO EXHIBITION GALLERIES


Smoker's lungs

### Smoker's Lungs and Enlarged Heart

This specimen displays an enlarged heart, a condition often resulting from high blood pressure or lack of oxygen to the heart muscle. These factors make the heart muscle work harder, causing it to grow in compensation. An enlarged heart generally does not mean a stronger heart.

If the strains on a heart are not reduced through diet, exercise, quitting smoking, or surgical intervention, the likelihood of a heart attack increases dramatically. An enlarged heat can be diagnosed by an echocardiogram, which allows a physician to study the heart's thickness, size, and function.

### Lung Cancer

One form of lung cancer known as bronchogenic carcinoma starts in lining of the lungs air passageways and not in the lung tissue itself. Lung cancer can go undetected for some time and thus have often advanced to a life-threatening stage before they are discovered. Early symptoms include a dry, irritated cough and the slow onset of breathlessness. The leading cause of lung cancer is chronic cigarette smoking.

### Section of Lung with Cancer

One form of lung cancer known as bronchogenic carcinoma starts in the lining of the lungs' air passageways and not in the lung tissue itself. Lung cancer can go undetected for some time and thus has often advanced to a life-threatening stage before they are discovered. Early symptoms include a dry, irritated cough and the slow onset of breathlessness. The leading cause of lung cancer is chronic cigarette smoking.

### Healthy Heart and Lungs

The heart is the king and the lungs are its ministers. This statement, made over four thousand years ago by Chinese physician Hwang Ti, is clearly evident with this specimen. While the lungs are responsible for oxygenating the blood, the heart must first circulate blood to the lungs where it is oxygenated and then subsequently pump it to every part of the body. The position of the heart between the lungs points to its central (and kingly) role in this important life-supporting process.


Healthy lungs

### Healthy Lungs

These healthy lungs show some dark pigmentation, the normal amount of discoloration that comes from inhaling the pollutants in our air. Special cells within the lungs sweep these pollutants out of the airway and deposit them in the lung tissue, allowing oxygen and carbon dioxide to be exchanged normally.

### Posterior Thoracic Wall, Posterior Mediastinum

The central portion of the thoracic cavity is called the mediastinum, a thick partition that contains the heart, esophagus, trachea, and the thymus gland. It lies in the midline of the chest, dividing it into two smaller compartments: the pleural cavities that hold the lungs.

# TEACHER'S GUIDE TO EXHIBITION GALLERIES

### Superficial Muscles of Face and Neck

Human facial muscles are among the most evolved of all mammals. With this complex set of muscles, we can express even the slightest emotion or feeling.

### Tongue, Pharynx, and Larynx

Taste buds associated with papillae found on the upper surface of the tongue help inform the brain what the body is ingesting and what enzymes it needs to break that food down. Each person has about 10,000 taste buds which are replaced every two weeks.

The pharynx, commonly known as the throat, is the common passage for air and food. The openings into the pharynx at the back of the mouth and the nose are provided with tonsils (mouth) and adenoids (nose), collections of lymphoid tissue that guard these major openings into the body and thus protect it from invading pathogens (viruses and bacteria). The pharynx also contains the epiglottis—a leaf-shaped flap of tissue behind the tongue that prevents food or liquid from entering the airway when swallowing.

The larynx (or voice box) forms the upper portion of the airway. It is held open by the hyoid, which protects the airway from being crushed. The larynx serves two main functions: to protect the airway to the lungs from inhaling food or water, and to produce a source of air vibration for the voice.

### Stomach

In the stomach, three layers of muscle churn partially digested food with powerful gastric juices, turning the food into a paste-like substance (chyme) and killing many bacteria that might otherwise bring disease to the body. Once food is broken down, it enters the duodenum, a ten-inch long, C-shaped section of the small intestine where food is further digested into amino acids, carbohydrates, nucleic acids, and fats: the four types of nutrients the body needs to sustain life.

### Rectum and Anal Canal

As it leaves the lower portion of the colon, undigested food and other body waste passes into the rectum where it is stored until the body discards it as feces through the anal canal. The rectum and the lower portion of the colon are sometimes the site of constipation. Generally caused by not enough fiber or liquid in the diet and a lack of exercise, constipation occurs when the feces hardens and becomes too dry to pass out of the anal canal.

### Duodenum, Pancreas, and Spleen

After food is broken down in the stomach, it enters the duodenum, a 10 inch-long, C-shaped section at the beginning of the small intestine. Here food is mixed with bile from the liver and enzymes from the pancreas to further digest it into carbohydrates, nucleic acids, amino acids, and fats—the four nutrients needed for life. These nutrients are then absorbed through the intestinal wall and enter the body via the bloodstream. The pancreas also plays a vital role in regulating blood sugar levels in the body, secreting the hormone insulin when blood sugar levels are high and the hormone glucagon when they are low.

# TEACHER'S GUIDE TO EXHIBITION GALLERIES

### Interior View of Small Intestine

The small intestine performs most of the digestion and absorption of nutrients in the digestive tract. Over ten feet long, it contains millions of villi and microvilli. These microscopic, finger-like projections reach into the hollow spaces of the small intestine increasing its surface area thousand of times. Through these projections, the end products of digestion pass into the bloodstream from where they are carried to the liver for further processing.

### Ileocecal Segment and Appendix

The ileocecal junction marks the end of the small intestine and the beginning of the large intestine. This is also the area that houses your appendix. A small pouch located at the bottom of the cecum, researchers now propose that the appendix serves as a safe haven for useful bacteria when illness flushes them from the rest of the intestines, a function that would be useful in sparsely populated areas where people would be less likely to pass these germs to one another.

### Muscles of Mastication, Tongue, and Taste Buds

Digestion of food begins in the mouth, with the teeth and tongue. The teeth tear, bite, and grind food (mastication), mixing it with saliva. The tongue moves food between the teeth to assist with chewing and swallowing. When food is swallowed, a cartilaginous flap of tissue, called the epiglottis, closes off the airway to prevent us from choking. Food then enters the esophagus, a 10-inch (25-centimeter) long muscular tube, where rhythmic muscular contractions (peristalsis) help transport it to the stomach.

Taste buds lie between the grooves on the surface of the tongue and tell the brain what the body is ingesting and what enzymes it needs to break it down. Each person has about 10,000 taste buds, with women generally having more than men.

### Liver with Gallbladder

The heaviest internal organ in the body, weighing close to 3.5 pounds (1.6 kilograms) in an average adult, the liver serves several metabolic functions. It produces bile, key to the proper digestion of fats, stores vitamin A, and creates several proteins essential to blood flow and clotting.

The gallbladder attaches to the lower surface of the liver and stores bile, a greenish-brown fluid that is essential for digestion. Bile breaks down fats and also helps carry certain toxic wastes created by the liver out of the body.

### Liver Blood Supply

The portal vein collects nutrient-rich blood from the veins leading from the large and small intestines, stomach, spleen, pancreas, and gallbladder. It then transports this blood to the liver, entering the organ through porta hepatic (Latin for "door to the liver") before ending as a network of capillaries in the liver called sinusoids. There bacteria and other debris are removed from the blood while nutrients are added to the blood or removed from it for storage. The blood then leaves the liver via the hepatic veins, which empty into the inferior vena cava.

# TEACHER'S GUIDE TO EXHIBITION GALLERIES

### Cirrhotic Liver

Along with storing sugars, the liver also removes and destroys ingested toxins, including alcohol, drugs, and microbes. The improper diet that often accompanies alcohol and drug abuse can lead to the death of liver cells and to their replacement by fatty scar tissue. This disease, called cirrhosis, has noticeably affected this specimen. Other diseases, such as liver cancer and hepatitis, can severely damage the liver as well.

### Cirrhotic Liver with Cancer

### Coronal Section of Male Trunk

### Digestive Organs + Blood Supply

In this specimen, the wall of the thoracic and abdominal cavities has been removed to show the position of the major organs located behind it.

### Core Organs

This classical pose offers you an exceptional view of many of the core organs of the thorax and abdomen, and helps illustrate the compact interrelationship of the organs working within you.

# TEACHER'S GUIDE TO EXHIBITION GALLERIES

### Uterus

The muscular wall of the uterus (womb) is the site where a fertilized egg implants, forms a placenta, and develops. It has a blood-rich lining that is shed each month (menstruation) if fertilization and implantation do not occur. It is the contraction of the smooth muscular wall of the uterus just prior to birth that is responsible for what people refer to as labor pains.

### Breasts Showing Glandular Tissue

The breasts, or mammary glands, consist of glandular tissue embedded in fat. Each breast is composed of 15 to 20 glands that produce milk following the birth of a child. A series of ducts transport milk from the glands to the nipple.

### Female Urogenital Organs

### Female Reproductive System

The various parts of the female reproductive system store, release, and incubate the female sex cell (ovum) that creates new human life when joined with a male sex cell (sperm).

Female eggs are the largest cells in the human body.

**1. Ovaries**—The female gonads; collectively they contain more than 250,000 ova, or eggs. All these eggs are present in the ovaries at birth. Alternating between left and right, the ovaries release an egg each month, a process called ovulation.

**2. Uterine (Fallopian) Tubes**—These open-ended tubes function to capture an egg when it breaks through the wall of the ovary and transport it to the uterus. Eggs are typically fertilized by the male sperm cell within the uterine tubes.

**3. Uterus (Womb)**—The site where a fertilized egg implants and develops. It has a blood-rich lining that is shed each month (menstruation), if fertilization does not occur.

**4. Cervix**—The lower portion of the uterus that opens into the vagina. The wall of the cervix is less muscular than that of the rest of the uterus. This allows it to soften and dilate prior to delivery for easier passage of the fetus into the birth canal. Cervical cancer is one of the most common cancers in women and can often be detected with a yearly Pap test.

**5. Vagina (Birth Canal)**—This fibro-muscular tube begins at the cervix and opens in association with external genitalia. It captures sperm, allowing them to reach the uterus and uterine tubes. It also expands during delivery to allow for childbirth.

**6. External Genitalia**—Consists of several protective folds of skin that surround the openings of the vagina and urethra.

# TEACHER'S GUIDE TO EXHIBITION GALLERIES

### Blood Vessels of the Kidney

This special dissection reveals the amazing network of blood vessels within the kidneys. Blood enters the kidney through the renal artery (visible in the center of this specimen) and passes into ever-smaller blood vessels until it reaches the capillaries that make up one of its over one million nephrons (filtering units). Here normal capillary pressure forces waste materials, water, electrolytes, and salts through small pores in the capillary wall leaving larger blood cells and blood proteins behind. Filtered blood returns to the general circulation via the renal veins, while the wastes formed within the kidneys (known as urine) flow through the ureters to reach the urinary bladder.

### Kidney

The key organs of the urinary system, the kidneys filter more than one liter of blood per minute, removing waste products and creating urine in the process. This specimen reveals the right-left relationship of the kidneys within your body and their relation to the body's main blood supply, the aorta.

Some of the kidney's inner structure is also exposed, including the renal artery, which delivers blood for filtering, and the renal cortex, where the actual filtration of blood occurs. The hollow space within the kidney is the renal sinus. It marks the beginning of the ureters, which carry urine drop by drop to the urinary bladder.

### Coronal Section of Kidney

### Kidney Showing Renal Artery

The renal arteries supply the kidney with blood. At any one time, over 30 percent of your blood is in the renal arteries.

### Arteries of the Kidneys

### Renal Pelvis

The renal pelvis is located near the center of the kidney. Its major function is to collect urine filtered out of the blood stream and funnel it towards the ureters, which carry it to the bladder, where it is held until it is expelled from the body.

### Mid-Sagittal Section of Male Pelvis

# TEACHER'S GUIDE TO EXHIBITION GALLERIES

### Penis, Bladder, and Prostate

The prostate gland surrounds the neck of the bladder and the urethra, the tube that carries urine from the bladder to the tip of the penis. Normally the size of a small walnut by age 50, it is common for the prostate to show some signs of enlargement, and its weight (normally about an ounce) may increase up to six times. This can cause an obstruction of urine flow from the bladder and, if uncorrected, can cause damage to the urinary bladder and the kidneys. Prostate enlargement is not an indication of prostate cancer, but may be a precursor to it. All men over the age of 50 should be screened yearly for prostate cancer.

### Male Urogenital Organs

### Male Reproductive System

The male reproductive system creates and delivers sperm, the male sex cell, which-when joined with the egg or female sex cell-causes fertilization. Its organs include:

**1. Testes (Testicles)**—Where sperm and hormones are produced. Because they best produce sperm at 3.5°F (2°C) below normal body temperature, the testes are contained within the scrotum outside of the main body cavity.

**2. Spermatic Cord**—Contains a duct (the ductus deferens) that carries sperm out of the testes. It also contains the testicular artery and the cremaster muscle, which lifts the testes closer to the body in cold weather.

**3. Seminal Vesicle**—Small glands that lie behind the urinary bladder, which secrete most (nearly 75 percent) of the seminal fluid.

**4. Prostate Gland**—Shaped like an inverted pyramid, the prostate surrounds the urethra as it leaves the urinary bladder. Its secretions accounts for approximately 25 percent of the seminal fluid.

**5. Penis**—Contains erectile tissue and a portion of the urethra, which carries urine and seminal fluid out of the body.

Male sperm are the smallest cells in the human body.

### Male Pelvis

The male pelvis has a heart-shaped inlet, a smaller outlet, and encloses a more cone-shaped and longer cavity than that found in women. It is also made up of larger bones and has greater joint surfaces. This structure allows the male pelvis to accommodate a generally stronger build and to support a greater amount of weight.

# TEACHER'S GUIDE TO EXHIBITION GALLERIES

### Reproductive Organs

The gonads are the reproductive organs that form the male and female gametes, cells that unite with each other during the process we know as fertilization. The name comes from an Ancient Greek word that translates as both wife (gamete) and husband (gametes). The female gamete (ovum) is produced by the ovaries, while in males it is produced by the testes (sperm).

### Testis

The male sex cell (sperm) is formed in the testis and then collect in the epididymis, where they mature and gain the ability to fertilize an egg cell (ova). During ejaculation sperm are transported from the epididymis via the peristaltic action of the smooth muscle within the wall of the vas deferens. During this process they are mixed with fluids secreted by the seminal vesicles, the prostate, and other glands, forming semen.

### Cross Section of Testis

### Cross Section of Ovary

The gonads contain cells that secrete the male and female reproductive hormones: the ovaries secrete estrogen and progesterone, while the testes secrete androgens. The primary and most well known androgen is the hormone testosterone.

### Female Pelvis

The female pelvic inlet and outlet are larger and more bell-shaped than those of the male pelvis. In addition the cavity it encloses is shorter, and its walls are more parallel than those found in men. It is these differences in shape that allows the female pelvis to accommodate the growing of the fetus and more comfortably deliver it, when it is fully developed, through the birth canal.

### Skeletal Muscles + Tendons / Strength Through Exercise

Dissected to reveal the skeletal muscles and the tendons, this specimen clearly demonstrates how skeletal muscles cover most of the body and account for much of our physical form.

This specimen exemplifies the muscular development that can be achieved through exercise and weight training.

# TEACHER'S GUIDE TO EXHIBITION GALLERIES

**If you wish to tour the Fetal Development gallery, continue with the Exhibition notes. If you do not wish to view the Fetal Development gallery, please turn to the notes for the Treated Body gallery.**

## All embryos and fetuses died of natural causes *in utero*.

**Blood Vessels of Placenta**

**Fetal Bone Development (24 weeks)**

**Fetal Bone Development (20 weeks)**

**Fetal Bone Development (18 weeks)**

**Fetal Bone Development (16 weeks)**

**Fetal Bone Development (14 weeks)**

**Fetal Heart and Lungs**

In the adult cardiovascular system, the heart is a double pump, delivering blood to the body and lungs. In the developing fetus, however, blood does not receive oxygen from the lungs, but via the umbilical cord and the placenta. For this reason, the heart of a fetus has an opening between its two upper chambers, bypassing the flow of blood to the lungs. Known as the foramen ovale, indicated by the red band in the center of this specimen, this opening in the heart wall closes shortly before birth. If it fails to close, deoxygenated blood is returned to general circulation, reducing oxygen level of in the blood. This makes a baby look blue and deprives it of the oxygen it needs to develop. Openings in the heart can now quickly be corrected through surgery.

# TEACHER'S GUIDE TO EXHIBITION GALLERIES

### Kidney Cancer
Very little is known about what causes cancer of the kidney, but research has shown that cigarette smoking increases the risk of developing kidney cancer, as does exposure to cadmium, mercury, lead, asbestos, and lead paints. Diabetes, obesity, chronic kidney failure, and high blood pressure may also increase the risk of developing kidney cancer. Those with a family history of kidney cancer should be checked regularly for this disease.

### Ovarian Cancer
Ovarian cancer occurs when normal ovarian cells begin to grow in an uncontrolled and abnormal manner, producing cancer in one or both of the ovaries. It is the 5th deadliest cancer among women.

### Cervical Cancer
There are two types of cervical cancer—squamous cell carcinoma (80% of all cases) and adenocarcinoma. Though cervical cancer is one of the most common cancers in women it does not form quickly, so it can often be detected with a yearly Pap test.

### Intestinal Leiomyoma
Intestinal leiomyoma is a benign tumor made up mostly of smooth muscle cells that usually occur in the intestinal wall. Though rare the prognosis is usually bleak. Since early symptoms are usually lacking or non-specific (such as general fatigue), these tumors are often not found until necrosis (cell and tissue death) and acute bleeding into the bowel occurs.

### Testicular Cancer
Although rare, testicular cancer is most often found in men between the ages of 15 and 35. It begins as a painless lump, which can be detected through self-examination. This cancer requires immediate removal of the diseased testicle. The remaining testicle, if unaffected, will continue to produce an adequate amount of sperm and testosterone.

# TEACHER'S GUIDE TO EXHIBITION GALLERIES

### Leiomyoma and Chronic Purulent Salpingitis

This specimen demonstrates two pathological conditions: 1) Leiomyoma of the uterus and 2) Chronic Purulent Salpingitis of the fallopian tubes.

A leiomyoma is a smooth muscle neoplasm (new growth) that may occur in any organ, but is most commonly found in the uterus, small intestine, and the esophagus. When growing within the uterus, is may lead to excessive menstrual bleeding, anemia, and eventually to infertility. Leiomyomas may be treated with conventional or laser surgery. Hormone suppression, especially of estrogen and progesterone, may also serve to decrease their size.

Salpingitis is the infection and subsequent inflammation of the fallopian tubes. Chronic salpingitis, seen here, is the milder form of the malady, but may be longer lasting than the acute. Normally, the infection originates in the vagina and subsequently ascends to the fallopian tube(s). More than 1 million cases are reported annually in the United States, and it is the most common infection for women aged 16–25. Infertility may result from repeated bouts of salpingitis, as the ovulated egg cannot reach the uterus. Women who conceive with this condition are 7–10 times more likely to have an ectopic pregnancy than those without. It is treated with antibiotics.

### Series of Thin Sagittal Sections

These thin sagittal slices through the body illustrate the cavities within our bodies and how our organs fit into them.

Body cavities include:
**Cranial**—The brain is well protected by the rigid bones surrounding it, but can easily be damaged if swollen.

**Thoracic**—The lungs fit snugly within the thorax (chest cavity)—so snugly in fact that the ribs and the other organs that surround them often leave "impressions" on their surfaces. This specimen's right lung has "costal" impressions from where it was pressed against the ribcage. The surface of each lung and the thoracic cavity in which they are located are covered/lined by a thin moist membrane (pleura). This provides a lubricated surface allowing the lungs to effectively expand and empty during respiration.

**Abdominal**—The important organs of digestion are contained within the abdominal cavity. The largest of these organs, the liver, lies at the top of this cavity, and presses up into the diaphragm. Notice the large space necessary to accommodate this organ. A tissue sheath called the peritoneum acts to hold the abdominal organs in place and provides some lubrication, allowing them to move and glide over one another with little friction.

**Pelvic**—The final portion of the large intestine, the urinary bladder, urethra, and reproductive organs are found within the pelvic cavity. Though no membrane separates it from the abdominal cavity, the pelvic cavity is noticeably narrower, and its lower end tilts towards the posterior of the body.

# TEACHER'S GUIDE TO EXHIBITION GALLERIES

### Exercise for Life
Exercise takes many forms and has many benefits. It can be used for muscle development and strength building and it can also provide a feeling of harmony and balance as expressed by this specimen's brisk walking pose.

### Inside + Out
Each of us is physically unique, from the shade of our skin to the size and shape of our organs.

### Femoral Osteosarcoma
Osteosarcoma is the most common type of malignant bone cancer, accounting for about 35% of all cases. It is most common in children and adults under the age of 30, and is the sixth leading cause of cancer in children under the age of 15.

### Language of Cancer
**Primary Site—**The site at which the original cancer develops.

**Secondary Site(s)—**The sites to which cancer spreads once it develops.

**Metastasis—**The process by which cancer cells spread from their primary site to other secondary sites in the body.

**Carcinoma—**A cancer that develops in cells that form the skin, glands, and the cells lining body organs.

**Sarcoma—**A cancer that develops from cells that form connective tissue, muscle, or bone.

### Pneumonia
Pneumonia is a serious lung disease in which inflammation—caused by bacteria and/or viruses—results in fluid and cellular debris in the air spaces of the lung that prevent gas exchange. It is a very common disease, occurring in about one percent of the population each year, and is most common in winter and spring because of sudden drops in air temperature and the prevalence of bacteria and viruses. Smoking, alcoholism, a poor immune system, and air pollution are all associated with an increased risk of pneumonia.

### Pulmonary Congestion
Pulmonary congestion (edema) is usually caused by high blood pressure that results in increased pressure in the lungs. Pulmonary congestion can be a complication of a heart attack, leaking or narrowed heart valves, or any disease of the heart that either results in weakening or stiffening of the heart muscle. The failing heart transmits its increased pressure to the lung veins. As pressure in the lung rises, fluid is pushed into the alveoli becoming a barrier to normal oxygen exchange. The result is shortness of breath.

### Humeral Cancer
Bone is constantly being remodeled so that it remains functionally strong. During this process specialized bone cells form new stronger bone, while at the same time others remove older weaker bone. Bone cells can divide in an uncontrollable fashion (become malignant) resulting in the type of bone cancer visible in the humerus (arm bone) shown here.

# TEACHER'S GUIDE TO EXHIBITION GALLERIES

### Esophageal Cancer

This is a serious form of cancer that starts in the inner layer of the esophagus, the 10-inch long tube that connects the throat to the stomach. The most common symptoms—which usually don't occur until the later stages of the disease—is difficulty swallowing and a sensation of food getting stuck in the throat or chest. Due to this late onset of symptoms, esophageal cancer survival rates are low, though they have improved somewhat recently.

### Tuberculosis in Portion of Right Lung

Tuberculosis (TB) is primarily an infection of the lungs in which an inhaled bacterium causes the formation of pockets, or tubercules, in lung tissue. These tubercules are groups of immune system cells surrounding the invading bacterium and an area of dead lung tissue. Often the disease stops here and lies dormant for many years. Serious complications occur when the bacteria spread throughout the lungs and to other parts of the body.

More than one-third of the world's population is infected with the tuberculosis bacterium, and it remains one of the leading causes of disease and death. Eight million people become sick from TB every year, and two million die from it.

### Transverse and Sagittal Human Sections

These body sections came from one specimen. They show you in actuality what Magnetic Resonance Imaging techniques (MRI) "see" when they scan a human body. MRI uses a magnetic field created by powerful electromagnets to stimulate hydrogen atoms in the body.

These atoms then give off radio signals that are collected by a special scanner and turned into images that look remarkably like the body segments you see here. Transverse body segments such as these, as well as the vertical segments elsewhere in this Exhibition, can assist physicians as they study relational anatomy, which is essential to reading MRI images.

# STUDENT GUIDE

Various systems of the body are represented inside this Exhibition. You will view both full bodies and individual organs that support the structure and function of that system. You will see first-hand some of the many things you have been studying at school.

Take your time going through the Exhibition. Read and see all that you can. Take notice of the plaques on the walls as they contain valuable information.

Remember that you are viewing real human bodies. Be respectful of them, your classmates and the other guests in the Exhibition. You will be assigned to a specific chaperone before you begin your tour. Keep your voices low and stay with your chaperone throughout each of the galleries. Also, you must turn off your cell phones.

Please be aware that food, drink and/or cameras are not allowed at any time. If you are completing a class assignment, we ask that you do not lean on the glass cases to write. Docents in white lab coats are available throughout the galleries to answer your questions. A children's audio tour, recorded for elementary level students, is available to order when you make your reservation. It tells an engaging story of the human body as you move through the galleries in the Exhibition.

You may be surprised to see that the full body specimens are displayed out in the open. You can view them as close as you like but please do not touch any of the bodies. The Interactive Desk at the end of the Exhibition offers you the opportunity to hold, feel and touch real organs from the body!

If you are interested in looking at the items in the retail store, please stay with your chaperone. The same is true for restroom breaks. Some of the more popular items in the store for students (from $4–$20) include shirts, key rings and magnets; and for teachers ($10–$40) you will find mugs, Exhibition Catalogs and poseable skeletons.

**Enjoy your remarkable journey through the human body.**

# STUDENT GUIDE

### Will we know who the body specimens are? How did they die?

Our suppliers have certified to us that they died from natural causes. All of the bodies and organ specimens in **BODIES REVEALED** came from individuals whose family members chose to donate their bodies to medical science for the purpose of study and education.

### Where do the specimens come from?

All of the bodies were obtained through plastination laboratories in the People's Republic of China. Asia possesses a large and highly competent group of anatomists and dissectors, who are essential to properly preparing these specimens for exhibition and educational purposes.

### How does it work?

Anatomists treat a specimen with chemicals to temporarily halt the decaying process. Then they dissect it to expose important structures.

All of the bodily fluids are removed from the specimen and replaced with a liquid called acetone.

In a vacuum, the acetone is removed and slowly replaced with plastic.

Lastly, the plastic silicone polymer hardens the body parts. The end result is a dry, odorless, permanently preserved specimen containing no toxic chemicals. It retains the look of the original but functions as if it were rubber.

### How long does it take to complete the preservation process?

Preparation time varies; a small organ may take only a week while a full body specimen may take up to one year to prepare.

# STUDENT GUIDE

**Complete these questions as you move through the Galleries.**

- Some questions can be answered by reading the **signs and labels**, some will be answered by **looking at the specimens** themselves, and some will require you to use **context clues**.
- Don't forget to use the process of elimination, apply what you may have seen or learned earlier, and use a good dose of healthy **common sense**!
- If you get stuck, find a person in a lab coat with an "**Ask Me**" button.

## SKELETAL SYSTEM

**1. What makes bones lighter and distributes force over a wide surface area?**
a. Marrow
b. Spongy bone tissue
c. Compact bone tissue
d. Cartilage

**2. The fontanelle is the soft spot on _____that will eventually harden.**
a. an adult's skull
b. an infant's stomach
c. an infant's skull
d. None of the above

**3. What is the difference in the total number of fetal bones and the total number of adult bones?**
a. 94
b. 0
c. 4
d. 206

**4. Which of these is an auditory ossicle?**
a. Malleas
b. Anvil or Incus
c. Stapes
d. All of the above

**5. Two bones found in the skull are the _____.**
a. tarsus and metatarsal
b. scapula and clavicle
c. sphenoid and temporal
d. xiphoid and zygomatic

**6. Examples of a ball and socket joint are your _____.**
a. Shoulder and hip
b. Neck and spine
c. Elbow and knee
d. Toe and finger

**7. Explain why infants have more bones than adults.**

**8. Describe the function of the auditory ossicles.**

**9. Name the three kinds of joints.**

**10. Describe the specific range of motion for the three kinds of joints.**

# STUDENT GUIDE

## MUSCULAR SYSTEM

**1. The muscular system is attached to which other system with tendons and ligaments throughout the body?**
a. Respiratory
b. Circulatory
c. Urinary
d. Skeletal

**2. The tongue is made up of _____ muscles.**
a. 2
b. 100
c. 16
d. 30

**3. About how many muscles are there in the human body?**
a. >600
b. <600
c. 1000
d. 60

**4. What are the names of the types of muscle tissue?**
a. Voluntary and involuntary
b. Cardiac, smooth, and skeletal
c. Motor, core, and dynamic
d. Supinator and pronator

**5. What is the largest muscle in the body?**
a. Heart
b. Gluteus maximus
c. Sartorius
d. None of the above

**6. How many muscles control the movement of the hand?**
a. One
b. About 40
c. About 20
d. About 10

**7. When a muscle is not used and it grows smaller, that is called _____.**
a. Muscular atrophy
b. Contraction
c. Teres major
d. Sternocleidomastoid

**8. What is the difference between the supinator muscle and the pronator?**

**9. Where in the body are these kinds of muscles found?**

**10. Explain the difference and give examples of voluntary and involuntary muscles.**

# STUDENT GUIDE

## NERVOUS SYSTEM

**1. The brain weighs _____ pounds.**
a. 0.6
b. 3
c. 12.6
d. 6

**2. Girls' brains account for 2.5% of their body weight. Boys' brains account for ____%.**
a. 3
b. 2.5
c. 2
d. 1.5

**3. What is the word for a place on the body where there is a dense network of peripheral nerves that come together in one spot?**
a. Plexus
b. Cerebellum
c. Cranial
d. Autonomic

**4. What is the longest nerve in the body?**
a. Spinal column
b. Femur
c. Synapse
d. Sciatic

**5. The function of the cerebellum is to control _____.**
a. equilibrium and muscular movement
b. vital body functions, such as breathing and digestion
c. connections between the right and left hemispheres
d. All of the above

**6. What is Dura Mater?**
a. Autonomic nerves that regulate the body's fight response.
b. Outer covering of the brain and spinal column.
c. Area of the lumbosacral plexus.
d. The anterior root of the spinal nerve.

**7. What protects the spinal cord?**
a. Vagus nerve
b. Medulla oblongata and cerebellum
c. Skull and vertebral column
d. Meninges and vertebrae

**8. Describe Carpal Tunnel Syndrome.**

**9. Describe the "pathway" used to innervate your pinky finger.**

**10. What causes a stroke? Describe the brain specimen that has had the stroke.**

# STUDENT GUIDE

## CIRCULATORY SYSTEM

**1. There are _____ miles of blood vessels in the adult human body.**
a. 10
b. 100
c. 1,000
d. 100,000

**2. When you feel your pulse, you are feeling a/an _____.**
a. vein
b. artery
c. ventricle
d. alveolus

**3. No cell in the body lies more than a few _____ from one of the body's blood vessels.**
a. inches
b. centimeters
c. millimeters
d. micrometers

**4. What happens in your circulatory system once every minute?**
a. Every drop of blood passes through the heart.
b. Every platelet becomes a white blood cell
c. Filaments of fibrin enmesh red blood cells as part of the clotting process.
d. None of the above.

**5. What prevents blood from flowing backwards?**
a. Veins have valves
b. The dorsal venous arches
c. Lymphocytes
d. Ventricles

**6. Of the 100% of the body's blood supply, how much is required by the brain?**
a. 0%
b. 2%
c. 20%
d. 100%

**7. Your heart is about the same size as your _____.**
a. head
b. fist
c. tongue
d. foot

**8. Describe the corrosion casting process used to prepare these specific specimens.**

**9. What is the difference between your blood vessels that appear to be red and those that appear to be blue?**

**10. What area of the head and skull has the greatest concentration of vessels? Why do you think this is the case?**

# STUDENT GUIDE

## RESPIRATORY SYSTEM

**1. A pack of cigarettes takes _____ off your life.**
a. 3 hours and 40 minutes
b. 7 minutes and 20 seconds
c. 2 years
d. no time

**2. What are the small ends of the bronchial tree that branch out like clusters in direct contact with capillary walls of the pulmonary veins?**
a. Diaphragm
b. Lobes
c. Alveoli
d. Trachea

**3. What organ is the only organ in the body that can float on water?**
a. the spleen
b. the heart
c. the lungs
d. the kidneys

**4. How many breaths do we take every minute?**
a. About 40 for babies and 15 for adults
b. About 50
c. About 40 for adults and 15 for babies
d. About 10

**5. What is the connection between the respiratory and circulatory systems?**
a. Oxygen from the respiratory system is absorbed into the bloodstream.
b. The blood carries the oxygen to every organ in the body.
c. Both a. and b.
d. None of the above.

**6. What is exchanged for oxygen in the lungs?**
a. Carbon monoxide
b. Water
c. Pulmonary arteries
d. Carbon dioxide

**7. What part of the respiratory system, which you may have also seen in another gallery, pushes and pulls the lungs to draw air in and out?**
a. Superior vena cava
b. Thoracic cavity
c. Bronchial tree
d. Diaphragm

**8. Compare the quality of healthy lungs to diseased lungs.**

**9. What do you think this statement, made over 4000 years ago by the Chinese physician, Hwang Ti, means? "The heart is the king and the lungs are its ministers."**

**10. Why do you think the bronchial tree segments are functionally separate regions in each lung?**

# STUDENT GUIDE

## DIGESTIVE SYSTEM

**1. What large organ is also the second heaviest organ of the body?**
a. Stomach
b. Lungs
c. Brain
d. Liver

**2. How long does it take for food to be absorbed in your small intestine?**
a. 4–8 seconds
b. 2–4 hours
c. 3–5 hours
d. 10 hours-several days

**3. What causes cirrhosis of the liver?**
a. Improper diet
b. Alcohol
c. Drug abuse
d. All of the above

**4. Where does the digestive tract begin?**
a. Mouth
b. Esophagus
c. Stomach
d. Colon

**5. What happens to the rugae when the stomach fills with food?**
a. The pancreas secretes juices into the gallbladder.
b. They expand to create more surface area.
c. It produces bile.
d. Arteries harden.

**6. What is the longest organ in the digestive system?**
a. Esophagus
b. Appendix
c. Large intestine
d. Small intestine

**7. What "extra" piece attached to the large intestine serves no discernible purpose and can be removed?**
a. Spleen
b. Appendix
c. Duodenum
d. Gall bladder

**8. How do you know when we have eaten enough? How does your stomach feel when you are full?**

**9. How is the surface area of the small intestine increased?**

**10. What is the "recipe" for digestion?**

# STUDENT GUIDE

## REPRODUCTIVE AND URINARY SYSTEM

**1. How many eggs, or ova, are contained in the ovaries?**
a. More than 250,000
b. About 2,500
c. Less than 250
d. 25

**2. What is the largest human cell?**
a. The chromosome
b. An egg
c. A sperm
d. The nucleus

**3. Which organ is found only in men and not in women?**
a. kidney
b. uterus
c. prostate
d. bladder

**4. What procedure can detect breast cancer in its early stages when highly treatable?**
a. Mammogram
b. Pelvic cavity
c. Lymphatic system
d. None of the above

**5. What are the parts of the urinary system?**
a. Ovary, uterine tubes, and kidneys
b. Small intestine, kidneys, and urethra
c. Ureter, bladder, and prostate
d. Kidney, ureters, and bladder

**6. What is the smallest human cell?**
a. An egg
b. The nucleus
c. The chromosome
d. A sperm

**7. How much blood per minute do your kidneys filter? Make a comparison to an everyday object of the same size. (For example, is it like a gallon of milk? A can of soda?)**

**8. Describe how the urine gets from the kidneys to the bladder.**

**9. What is the function of the prostate gland?**

**10. What is the function of the fallopian tubes?**

# STUDENT GUIDE

## FETAL DEVELOPMENT

**This assignment is optional depending on your level of sensitivity to this part of the Exhibition. Please write 1–2 paragraphs on your reaction to this gallery.**

## THE TREATED BODY

**Now that you have seen many examples of the Polymer Preservation Process, explain it in your own words.**

**Explain how the specimen with sliced sections demonstrates an MRI.**

# STUDENT GUIDE

## DISCUSSION AND REFLECTION

**Take some time to record your reflections about your experience at BODIES REVEALED. You should fill at least the back of this page or use separate paper.**

1. What was your first reaction when you entered the Exhibition? How did your reactions change by the time you got to the end, if they changed at all?

2. How did the bodies look different from what you've seen in textbooks?

3. Which gallery did you react to the strongest? Which gallery was most memorable? Why?

4. List 5 things you saw that you learned about in class.

5. List 5 things you saw that you never heard of before and found interesting.

6. What are 3 questions you still have about the human body and want answered when we return to class?

7. Would you recommend this Exhibition to other people? Why or why not?

# STUDENT GUIDE

### Skeletal System

1. b 2. c 3. a 4. d 5. c 6. a
7. The skull bones, among others, fuse with age.
8. malleus = hammer, incus = anvil, stapes = stirrup; connected by the smallest movable joints in the body, these bones transfer sound vibrations from the surface of the eardrum to the inner ear
9. hinge, ball & socket, pivot
10. hinge allows the joint to swing in 2 directions; ball & socket allows some

### Muscular System

1. d 2. c 3. a 4. b 5. b 6. c 7. a
8. They are opposite, or antagonistic, because they work in opposite motions.
9. In the forearm, the supinator helps you rotate and turn your palm upward; the pronator lets you turn your palm down. (also in the foot)
10. voluntary: movements under your control, quadriceps; involuntary: muscles that work without any direction from you, heart

### Nervous System

1. b 2. c 3. a 4. d 5. a 6. b 7. d
8. numbness and pain in the thumb and middle finger, occurs when tendons become inflamed and press on the median nerve where it passes though the carpal tunnel to the wrist
9. brain to spinal cord through brachial plexus to ulnar nerve to little finger
10. blockage or rupture in one or more blood vessels, blood supply to the brain is interrupted' stroke brain has black areas

### Circulatory System

1. d 2. b 3. d 4. a 5. a 6. c 7. b
8. Blood vessels are injected with a colored polymer, which then hardens. The remaining body tissues are then chemically removed to reveal the matrix that transports blood.
9. blue for veins, red for arteries
10. face, eyes/nose/mouth

### Respiratory System

1. a 2. c 3. c 4. a 5. c 6. d 7. d
8. healthy, pinkish white lung vs. smokers black lungs
9. The lungs serve the heart by bringing it oxygen, like the ministers served the king. The lungs also surround the heart.
10. It is nature's way of ensuring that breathing will continue if other parts of the lung become damaged.

### Digestive System

1. d 2. c 3. d 4. a 5. b 6. d 7. b
8. You feel "full". Your stomach feels stretched and tight. Nerve receptors in the stomach send a message to the brain telling it that the rugae are already stretched out far enough.
9. with villi (or microvilli)
10. Ingest, chew (10–30 times), swallow (4 seconds), churn (2–4 hours), absorb (3–5 hours), compact (10 hours–several days), eliminate

### Reproductive & Urinary System

1. a 2. b 3. c 4. a 5. d 6. d
7. about 2 liters of blood, or 3 pints; about the size of a big soda bottle
8. Urine travels by muscular contractions through the ureters one drop at a time to the bladder where it is stored.
9. supplies semen with 25% of its fluid—mainly an alkaline solution that neutralizes the vagina's acidity, allowing the sperm to live
10. transports egg cells from the ovaries to the uterus

### The Treated Body

**Preservation Process:**

1. the human specimen is temporarily preserved to stop decay
2. the specimen is dissected to feature specific systems and structures
3. the dissection is immersed in acetone to evacuate all body water
4. dehydrated, the specimen is placed in a silicone polymer bath and sealed in a vacuum chamber
5. under vacuum, the acetone leaves the body in gas form, replaced by silicone polymer
6. the silicone polymer hardens in curing
7. the permanently preserved specimen is ready for study

**MRI:**

Explanation should include concept of how magnetic resonance allows the body to be seen in "layers."

# GLOSSARY OF TERMS

**Alveoli**: (āl-vē'ə-ləs) a small cavity or pit: as **a:** a socket for a tooth **b:** an air cell of the lungs **c:** an acinus of a compound gland **d:** any of the pits in the wall of the stomach into which the glands open

**Antagonist Muscle:** a muscle that contracts with and limits the action of an agonist with which it is paired

**Appendix:** narrow blind tube usually about three or four inches (7.6 to 10.2 centimeters) long that extends from the cecum in the lower right-hand part of the abdomen, has much lymphoid wall tissue, normally communicates with the cavity of the cecum, and represents an atrophied terminal part of the cecum

**Artery:** any of the tubular branching muscular- and elastic-walled vessels that carry blood from the heart through the body

**Articulation:** a joint between bones or cartilages in the vertebrate skeleton that is immovable when the bones are directly united, slightly movable when they are united by an intervening substance, or more or less freely movable when the articular surfaces are covered with smooth cartilage and surrounded by an articular capsule

**Atrium:** an anatomical cavity or passage ; *especially:* a chamber of the heart that receives blood from the veins and forces it into a ventricle or ventricles

**Autonomic Nervous System:** part of the vertebrate nervous system that innervates smooth and cardiac muscle and glandular tissues and governs involuntary actions (as secretion, vasoconstriction, or peristalsis) and that consists of the sympathetic nervous system and the parasympathetic nervous system—called also *vegetative nervous system*

**Birth Canal:** the channel formed by the cervix, vagina, and vulva through which the mammalian fetus is expelled during birth

**Bone Marrow:** a soft highly vascular modified connective tissue that occupies the cavities and cancellous part of most bones and occurs in two forms: **a:** a whitish or yellowish bone marrow consisting chiefly of fat cells and predominating in the cavities of the long bones

**Bone:** one of the hard parts of the skeleton of a vertebrate

**Bronchi:** either of the two primary divisions of the trachea that lead respectively into the right and the left lung

**Bronchial Tree:** the bronchi together with their branches

**Cardiac Muscle Tissue:** named because it is found in the heart. Cells are joined to one another by intercalated discs which allow the "synchronization" of the heartbeat. Cardiac muscle is branched, striated muscle.

**Cartilage:** a usually translucent somewhat elastic tissue that composes most of the skeleton of vertebrate embryos and except for a small number of structures (as some joints, respiratory passages, and the external ear) is replaced by bone during ossification in the higher vertebrates

**CAT Scan:** a sectional view of the body constructed by computed tomography

**Cecum:** (sē'kəm) a cavity open at one end (as the blind end of a duct); *especially:* the blind pouch at the beginning of the large intestine into which the ileum opens from one side and which is continuous with the colon

**Central Nervous System:** the part of the nervous system which in vertebrates consists of the brain and spinal cord, to which sensory impulses are transmitted and from which motor impulses pass out, and which supervises and coordinates the activity of the entire nervous system

**Cervix:** a constricted portion of an organ or part: as **a:** the narrow lower or outer end of the uterus **b:** the constricted cementoenamel junction on a tooth

**Colon:** the part of the large intestine that extends from the cecum to the rectum

**Compact Bone Tissue:** The compact noncancellous portion of bone that consists largely of concentric lamellar osteons and interstitial lamellae

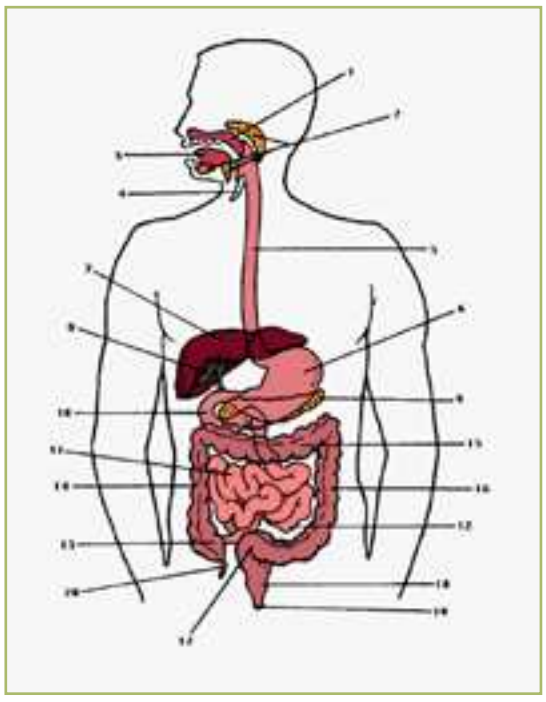
**Conchae:** (käŋ-kə) the largest and deepest concavity of the external ear

**Contraction:** (kən-trāk'shən) **n:** the shortening and thickening of a functioning muscle or muscle fiber

# GLOSSARY OF TERMS

**Diaphragm:** a body partition of muscle and connective tissue; *specifically:* the partition separating the chest and abdominal cavities in mammals

**Digestion:** 1 palate, 2 salivary glands, 3 tongue, 4 epiglottis, 5 esophagus, 6 stomach, 7 liver, 8 gallbladder, 9 pancreas, 10 duodenum, 11 jejunum, 12 ileum (10, 11, and 12 comprise the small intestine), 13 cecum, 14 ascending colon, 15 transverse colon, 16 descending colon, 17 sigmoid flexure, 18 rectum (13–18 comprise the large intestine), 19 anus, 20 vermiform appendix



**Duodenum:** (dü-ə-ˈdē-nəm) the first, shortest, and widest part of the small intestine that in humans is about 10 inches (25 centimeters) long and that extends from the pylorus to the undersurface of the liver where it descends for a variable distance and receives the bile and pancreatic ducts and then bends to the left and finally upward to join the jejunum near the second lumbar vertebra

**Epididymus:** (e-pə-ˈdi-də-məs) a system of ductules that emerges posteriorly from the testis, holds sperm during maturation, and forms a tangled mass before uniting into a single coiled duct which comprises the highly convoluted body and tail of the system and is continuous with the vas deferens

**Foramen (Foramina):** (fə-ˈrā-mən) a small opening, perforation, or orifice

**Glial Cells:** (glē-əl) of, relating to, or comprising neuroglia

**Gray Matter:** neural tissue especially of the brain and spinal cord that contains cell bodies as well as nerve fibers, has a brownish gray color, and forms most of the cortex and nuclei of the brain, the columns of the spinal cord, and the bodies of ganglia

**Ilium:** (il-ē-əm) the dorsal, upper, and largest one of the three bones composing either lateral half of the pelvis that in humans is broad and expanded above and narrower below where it joins with the ischium and pubis to form part of the acetabulum

**Internal Respiration:** the exchange of gases (as oxygen and carbon dioxide) between the cells of the body and the blood by way of the fluid bathing the cells

**Jejunum:** the section of the small intestine that comprises the first two fifths beyond the duodenum and that is larger, thicker-walled, and more vascular and has more circular folds and fewer Peyer's patches than the ileum

**Ligament:** a tough band of tissue that serves to connect the articular extremities of bones or to support or retain an organ in place and is usually composed of coarse bundles of dense white fibrous tissue parallel or closely interlaced, pliant, and flexible, but not extensible

**Liver:** a large very vascular glandular organ of vertebrates that secretes bile and causes important changes in many of the substances contained in the blood which passes through it (as by converting sugars into glycogen which it stores up until required and by forming urea), that in humans is the largest gland in the body, weighs from 40 to 60 ounces (1100 to 1700 grams)

# GLOSSARY OF TERMS

**MRI:** magnetic resonance imaging—a noninvasive diagnostic technique that produces computerized images of internal body tissues and is based on nuclear magnetic resonance of atoms within the body induced by the application of radio waves

**Neuroglia:** (neu·ro·gli·al) supporting tissue that is intermingled with the essential elements of nervous tissue especially in the brain, spinal cord, and ganglia, is of ectodermal origin, and is composed of a network of fine fibrils and of flattened stellate cells with numerous radiating fibrillar processes

**Neuron:** one of the cells that constitute nervous tissue, that have the property of transmitting and receiving nervous impulses

**Ovary:** one of the typically paired essential female reproductive organs that produce eggs and in vertebrates female sex hormones, that occur in the adult human as oval flattened bodies about one and a half inches (four centimeters) long suspended from the dorsal surface of the broad ligament of either side, that arise from the mesonephros, and that consist of a vascular fibrous stroma enclosing developing egg cells

**Pancreas:** (paŋ-krē-əs) a large lobulated gland that in humans lies in front of the upper lumbar vertebrae and behind the stomach and is somewhat hammer-shaped and firmly attached anteriorly to the curve of the duodenum with which it communicates through one or more pancreatic ducts and that consists of (1) tubular acini secreting digestive enzymes which pass to the intestine and function in the breakdown of proteins, fats, and carbohydrates; (2) modified acinar cells that form islets of Langerhans between the tubules and secrete the hormones insulin and glucagon; and (3) a firm connective-tissue capsule that extends supportive strands into the organ

**Peripheral Nervous System:** the part of the nervous system that is outside the central nervous system and comprises the cranial nerves excepting the optic nerve, the spinal nerves, and the autonomic nervous system

**Peristalsis:** (per-ə-ˈstȯl-səs) successive waves of involuntary contraction passing along the walls of a hollow muscular structure (as the esophagus or intestine) and forcing the contents onward

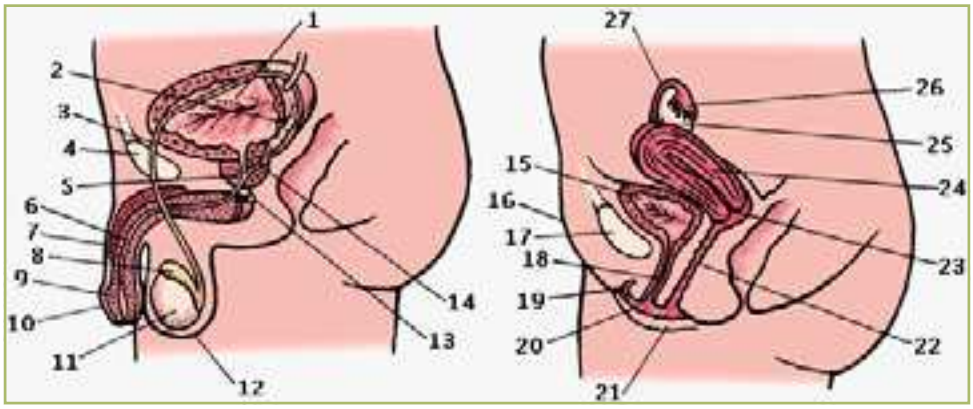
**Placenta:** the vascular organ in mammals except monotremes and marsupials that unites the fetus to the maternal uterus and mediates its metabolic exchanges through a more or less intimate association of uterine mucosal with chorionic and usually allantoic tissues permitting exchange of material by diffusion between the maternal and fetal vascular systems but without direct contact between maternal and fetal blood and typically involving the interlocking of fingerlike vascular chorionic villi with corresponding modified areas of the uterine mucosa

**Prime Mover:** a muscle that on contracting is automatically checked and controlled by the opposing simultaneous contraction of another muscle—called also agonist muscle

**Prostate:** a firm partly muscular partly glandular body that is situated about the base of the mammalian male urethra and secretes an alkaline viscid fluid which is a major constituent of the ejaculatory fluid

**Prosthesis:** an artificial device to replace or augment a missing or impaired part of the body

# GLOSSARY OF TERMS




**Reproductive System:** left male, right female. 1 bladder, 2 seminal vesicle, 3 vas deferens, 4 pubic symphysis, 5 prostate, 6 urethra, 7 penis, 8 epididymis, 9 glans penis, 10 foreskin, 11 testis, 12 scrotum, 13 Cowper's gland, 14 ejaculatory duct, 15 bladder, 16 mons pubis, 17 pubic symphysis, 18 urethra, 19 clitoris, 20 labia minora, 21 labia majora, 22 vagina, 23 cervix, 24 uterus, 25 ovary, 26 fimbria, 27 fallopian tube

**Rugae:** (rü-gə) an anatomical fold or wrinkle especially of the viscera—usually used in plural (the *rugae* of an empty stomach)

**Seminal Vesicle:** either of a pair of glandular pouches that lie one on either side of the male reproductive tract and that in human males secrete a sugar- and protein-containing fluid into the ejaculatory duct

**Skeletal Muscle Tissue:** attached to bones by tendons, is associated with the body's voluntary movements. Skeletal muscle is striated muscle. Unlike cardiac muscle, the cells are not branched.

**Smooth Muscle Tissue:** muscle tissue that lacks cross striations, that is made up of elongated spindle-shaped cells having a central nucleus, and that is found in vertebrate visceral structures (as the stomach and bladder) as thin sheets performing functions not subject to conscious control by the mind and in all or most of the musculature of invertebrates other than arthropods

**Spongy Bone Tissue:** Bone in which the spicules form a latticework, with interstices filled with embryonic connective tissue or bone marrow.

**Synapse:** the place at which a nervous impulse passes from one neuron to another

**Synergist Muscle:** an organ (as a muscle) that acts in concert with another to enhance its effect

**Tendon:** a tough cord or band of dense white fibrous connective tissue that unites a muscle with some other part, transmits the force which the muscle exerts, and is continuous with the connective-tissue epimysium and perimysium of the muscle and when inserted into a bone with the periosteum of the bone

**Testes:** typically paired male reproductive gland that usually consists largely of seminiferous tubules from the epithelium of which spermatozoa develop, that corresponds to the ovary of the female and in craniate vertebrates develops from the genital ridges of the embryo, and that in most mammals descends into the scrotum before the attainment of sexual maturity and in many cases before birth

**Trabeculae:** (trə-ˈbek-yə-lə) one of a pair of longitudinally directed more or less curved cartilaginous rods in the developing skull of a vertebrate that develop under the anterior part of the brain on each side of the pituitary gland and subsequently fuse with each other and with the parachordal cartilages to form the base of the cartilaginous cranium

# GLOSSARY OF TERMS

**Trachea:** (trā-kē-ə) the main trunk of the system of tubes by which air passes to and from the lungs that is about four inches (10 centimeters) long and somewhat less than an inch (2.5 centimeters) in diameter, extends down the front of the neck from the larynx, divides in two to form the bronchi, has walls of fibrous and muscular tissue stiffened by incomplete cartilaginous rings which keep it from collapsing, and is lined with mucous membrane whose epithelium is composed of columnar ciliated mucus-secreting cells

**Turbinates:** any of three thin bony plates on the lateral wall of the nasal fossa on each side with or without their covering of mucous membrane: a separate curved bony plate that is the largest of the three and separates the inferior and middle meatuses of the nose—called also *inferior concha, inferior nasal concha, inferior turbinate, inferior turbinate bone, maxilloturbinal*

**Urethra:** the canal that in most mammals carries off the urine from the bladder and in the male serves also as a genital duct

**Uterine Tube:** (Fallopian tube) either of the pair of tubes that carry the eggs from the ovary to the uterus

**Uterus:** an organ in female mammals for containing and usually for nourishing the young during development previous to birth that consists of a greatly modified and enlarged section of an oviduct or of the two oviducts united, that has thick walls consisting of an external serous coat, a very thick muscular coat of smooth muscle, and a mucous coat containing numerous glands, and that during pregnancy undergoes great increase in size and change in the condition of its walls called also—*womb*

**Vas Deferens:** a sperm-carrying duct especially of a higher vertebrate that in humans is a small but thick-walled tube about two feet (0.6 meter) long formed by the union of the vasa efferentia, is greatly convoluted in its proximal portion, begins at and is continuous with the tail of the epididymis, runs in the spermatic cord through the inguinal canal, and descends into the pelvis where it joins the duct of the seminal vesicle to form the ejaculatory duct

**Vein:** any of the tubular branching vessels that carry blood from the capillaries toward the heart and have thinner walls than the arteries and often valves at intervals to prevent reflux of the blood which flows in a steady stream and is in most cases dark-colored due to the presence of reduced hemoglobin

**Ventricle:** cavity of a bodily part or organ; as **a:** a chamber of the heart which receives blood from a corresponding atrium and from which blood is forced into the arteries **b:** one of the system of communicating cavities in the brain that are continuous with the central canal of the spinal cord, that like it are derived from the medullary canal of the embryo, that are lined with an epithelial ependyma, and that contain a serous fluid **c:** a fossa or pouch on each side of the larynx between the false vocal cords above and the true vocal cords below

**White Matter:** neural tissue that consists largely of myelinated nerve fibers, has a whitish color, and underlies the gray matter of the brain and spinal cord or is gathered into nerves