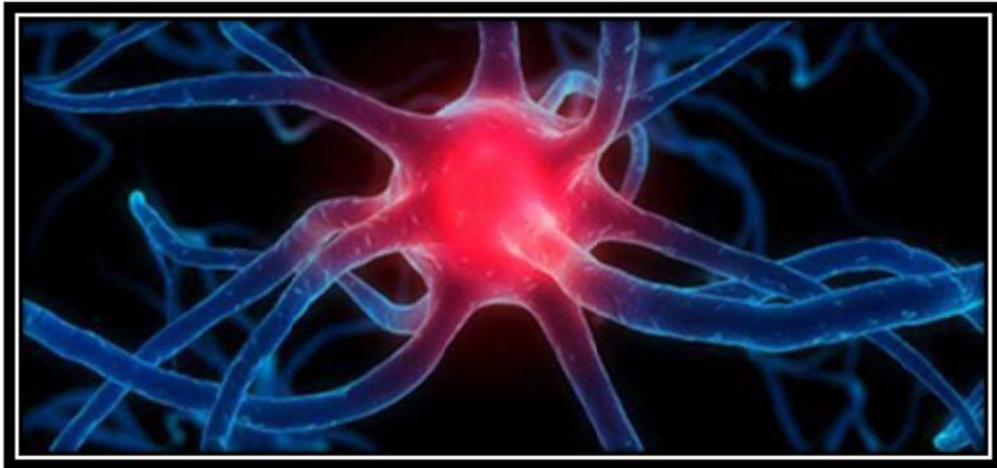


# LIFE SCIENCE 2

A comprehensive course that teaches the fundamental concepts in human physiology and anatomy. Students will discover how to build a working robotic hand, measure their lung capacity, filter blood, detect genetic traits, chemically fingerprint their friends, and make a frog totally disappear.



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This curriculum is aligned with the National Standards and STEM for Science.

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# Introduction

Greetings and welcome to the study of Human Anatomy. This unit was created by a mechanical engineer, university instructor, airplane pilot, astronomer, robot-builder and real rocket scientist... me! I have the happy opportunity to teach you everything I know over the next set of lessons. I promise to give you my best stuff so you can take it and run with it... or fly!

To get the most out of these labs, there are really only a couple of things to keep in mind. Since we are all here to have fun and learn something new, this shouldn't be too hard.

One of the best things you can do as the student is to cultivate your curiosity about things. *Why did that move? How did that spin? What's really going on here?*

This unit on Human Anatomy is chock full of demonstrations and experiments for two big reasons. First, they're fun. But more importantly, the reason we do experiments in science is to hone your observational skills. Science experiments really speak for themselves much better than I can ever put into words or show you on a video. And I'm going to hit you with a lot of these science demonstrations and experiments to help you develop your observing techniques.

Scientists not only learn to observe what's going on in the experiment, but they also learn how to observe what their experiment is telling them, which is found by looking at your data. It's not enough to invent some new kind of experiment if you don't know how it will perform when the conditions change a bit, like on Mars. We're going to learn how to predict what we think will happen, design experiments that will test this idea, and look over the results we got to figure out where to go from there. Science is a process, it's a way of thinking, and we're going to get plenty of practice at it.

Good luck with this *Life Science: Human Anatomy* unit!

# For the Parent/Teacher:

## Educational Goals for Life Science 1

Your body does a tremendous number of things all the time. You're going to learn about your skeleton, bone joints, muscle tension, blood cells, lungs, ears, and eyes! Some of the experiments you'll be creating include: a working lung model so you can see how pressure differences affect the lungs and diaphragm; a robotic hand model with real tendons; working eye model which you can adapt for near- and farsighted conditions; how to do chemical fingerprinting... and so much more!

We will go over integumentary, skeletal, and muscular systems by beginning with a general overview of the body. We'll also learn about what we should eat and discover what happens to food once we swallow it. Another system we'll cover is the respiratory system, which is responsible for providing your organs with the oxygen they need and removing the carbon dioxide they don't. Speaking of things your body doesn't need, our next topic will be the excretory system, the one responsible for getting rid of all waste from the body. We'll talk about how your body allows you to do all the things you do. In order to do those things, your body must stay healthy, and keeping you healthy is the job of the immune system.

### **Here are the scientific concepts:**

1. An inherited trait can be determined by one or more genes.
2. The sequential steps of digestion, and the roles of teeth and mouth, esophagus, stomach, small intestine, large intestine, and colon in the function of the digestive system.
3. Organ systems function because of the contributions of individual organs, tissues, and cells. The failure of any part can affect the entire system.
4. How bones and muscles work together to provide a structural framework for movement.
5. How to relate the structures of the eye and ear to their functions.
6. How to compare joints in the body (wrist, shoulder, thigh) with structures used in machines and simple devices (hinge, ball-and-socket, and sliding joints).
7. How levers confer mechanical advantage and how the application of this principle applies to the musculoskeletal system.
8. How kidneys remove cellular waste from blood and convert it into urine, which is stored in the bladder.
9. How blood circulates through the heart chambers, lungs, and body, and how carbon dioxide (CO<sub>2</sub>) and oxygen (O<sub>2</sub>) are exchanged in the lungs and tissues.
10. Contractions of the heart generate blood pressure, and heart valves prevent backflow of blood in the circulatory system.
11. How the five senses (sight, smell, sound, taste, and touch) work together.

### **By the end of the labs in this unit, students will be able to:**

- Design and build a working robotic hand by understanding how tendons work to create movement.
- Know how to demonstrate how the eye works, and demonstrate common eye problems.
- Understand how to determine lung capacity, monitor heart rate, and several other measurable functions of the body.
- Demonstrate how the body can be modeled by simple machines and joint models.

- Differentiate observation from inference (interpretation) and know scientists' explanations come partly from what they observe and partly from how they interpret their observations.
- Measure and estimate the weight, length and volume of objects.
- Formulate and justify predictions based on cause-and-effect relationships.
- Conduct multiple trials to test a prediction and draw conclusions about the relationships between predictions and results.
- Construct and interpret graphs from measurements.
- Follow a set of written instructions for a scientific investigation.

# Master Materials List for All Labs

This is a brief list of the materials that you will need to do *all* of the activities, experiments and projects in this unit. The set of materials listed below is just for one lab group. Most materials are reusable. Parts numbers are from [www.hometrainingtools.com](http://www.hometrainingtools.com) unless noted.

#3 one-hole stopper (CE-STOP03A)	fabric (1 small piece)	pH paper strips (CH-PHSTRIP)
"Y" hose connector (CE-TUBEY)	fan (variable-speed)	PTC paper (CH-PTCTEST)
aluminum tart pan	film canisters (10)	red disclosing tablets (from your dentist)
ammonia	funnel (CE-FUNNEL)	red food dye
ammonium nitrate (UN1942)	garlic (fresh, one clove)	red vinegar
baggie, gallon size	garlic press	rice
baggies (6, re-sealable)	glass jar	rubber band
baking soda	gloves	rubber bands (8)
balloons (4 round, 9-inch)	goggles	rubbing alcohol
bathroom scale	"goldenrod" colored paper	salt
beans	ground cinnamon	salty and soda crackers
double convex lens (OP-LEN4X30)	hard-boiled egg	sand
black coffee (1 cup)	hose (4') (CE-TUBERU2)	sandpaper
black marker, permanent	hot glue with glue sticks	sawdust (or pencil shavings)
black tea (1 bag)	iodine (CH-IODINE)	scissors
blindfold	kitchen knife (with adult help)	scrap of cardboard
bromothymol blue (CH-BROMOBL)	large plastic bowl	shoeboxes with lids (4)
calcium chloride (CH-CACL2)	latex gloves	small containers with lids (10)
chalk	lemon	soda (like cola)
cinnamon oil	liquid crystal thermometer ( <a href="http://www.teachersource.com">www.teachersource.com</a> LC-2530B)	soda bottle (2)
clock with second hand	magnifying lens	soup can
coffee filter or cheesecloth	matches	soy sauce
cotton balls (11)	measuring cups	spoons
cotton swabs (4)	meterstick or yardstick	straws (50)
craft stick	microscope slide (MS-SLIDEPL)	straws, flexible (5)
cups (8)	microwave	string, 12 inches long
cutting board	mirror	styrofoam cups
dark or bitter chocolate	newsprint with small type	sugar
dime	nylon stockings (one old pair)	tape
disposable cups	onion	tennis ball
distilled white vinegar	paper plates (2)	thermometer
drill (with adult help)	paper towel	toilet paper tube
energy drink, like Gatorade	paperclips	toothpicks (2)
eyedropper (CE-DROPPER)	pennies	vanilla extract
	petroleum jelly (or lip balm)	votive candle
		washer (3/8" inside diameter)

# Lab Safety

**Goggles:** These should be worn when working with chemicals, heat, fire, or projectiles. These protect your eyes from chemical splatter, explosions, and tiny fast-moving objects aimed at the eyes. If you wear glasses, you can find goggles that fit over them. Don't substitute eyeglasses for goggles, because of the lack of side protection. Eyeglasses don't provide this important side eye protection.

**Clean up Messes:** Your lab area should be neat, organized, and spotless before you start, during your experiment, and when you leave. Scientists waste more time hunting for lost papers, pieces of an experiment, and trying to reposition sensitive equipment... all of which could have easily been avoided had they been taught organizational skills from the start.

**Dispose of Poisons:** If a poisonous substance was used, created, or produced during your experiment, you must follow the proper handling procedures for disposal. You'll find details for this in the experiments as needed.

**Special Notes on Batteries:** Do not use alkaline batteries with your experiments. Find the super-cheap kind of batteries (usually labeled "Heavy Duty" or "Super Heavy Duty") because these types of batteries have a carbon-zinc core, which does not contain the acid that alkaline batteries have. This means when you wire up circuits incorrectly (which you should expect to do because you are learning), the circuits will not overheat or leak. If you use alkaline batteries (like Energizer and Duracell) and your students short a circuit, their wires and components will get super-hot and leak acid, which is very dangerous.

**No Eating or Drinking in the Lab:** All foods and drinks are banned from your classroom during science experimentation. When you eat or drink, you run the very real risk of ingesting part of your experiment. For electricity and magnetism labs, always wash your hands after the lab is over to rinse off the lead from the electrical components.

**No Horse Play:** When you goof around, accidents happen, which means chemicals spill, circuits short, and all kinds of hazards can occur that you weren't expecting. Never throw anything to another person and be careful where you put your hands – it could be in the middle of a sensitive experiment, especially with magnetism and electricity. You don't want to run the risk of getting shocked or electrified when it's not part of your experiment.

**Fire:** If you think there's a fire in the room (even if you're not sure), let your teacher know right away. If they are not around (they always should be), smother the fire with a fire blanket or use a fire extinguisher and send someone to find an adult. Stop, drop, and roll!

**Questions:** If you're not sure about something stop and ask, no matter what it's about. If you don't know how to properly handle a chemical, do part of an experiment, ask! If you're not comfortable doing part of the experiment, then don't do it.



# Lesson #1: Robotic Hand

**Overview:** Your body moves with the muscles pull on the bones through ligaments and tendons. Ligaments attach the bones to other bones, and the tendons attach the bones to the muscles. If you place your relaxed arm on a table, palm-side up, you can get the fingers to move by pushing on the tendons below your wrist. We're going to make a real working model of your hand, complete with the tendons that move the fingers! Are you ready?

## Materials

- flexible straws (5)
- scrap of cardboard (at least as big as your hand)
- rubber bands (5)
- string or thin rope (5 feet total, and a lighter with adult help if you're using nylon rope)
- hot glue with glue sticks
- scissors
- razor
- pen

## Experiment

1. Using the pen, trace a grown-up's hand on the cardboard.
2. Cut out the hand shape with scissors, or a razor (with adult help). If using a razor, also round off the tips of the fingers using scissors.
3. Place your hand palm up beside the cardboard cutout. Use your hand as a guide to mark approximately where the segments of your hands are on the cardboard.
4. The lowest segment lines are probably below the cut portion of the cardboard, so use the scissors to cut the cardboard fingers apart down to the first segment line.
5. Be sure there is a segment line that indicates the mound where your thumb bends into the palm.
6. Open up the flexible part of the straws. Take the first straw and line it up with the bottom of the cardboard hand, making sure the bendy part is about halfway up the cardboard palm.
7. Make a stripe of hot glue down the cardboard. Then place the straw on the cardboard hand and reinforce it with an extra stripe of glue down either side of the straw. Do this for each finger. If you can't get to each side, it's fine to do only one.
8. For the thumb, place the flexible portion a little further down so that the straw overhangs the bottom of the hand. Flip over the hand to trim off this excess and also trim the excess straw from the top of each finger.
9. You will need adult help to notch the straws. Note the guidelines you drew for each finger segment. Holding the razor blade at a 45° angle, carefully pierce the straw and slice downwards. Do this on each side of the line and for each segment of each finger and thumb. Be sure to make a wide enough notch to allow for a good range of motion for your hand.
10. Noting the notch positions from the side of the hand, turn the hand over and score **ONLY** the top layer of cardboard. This allows the fingers to move, but keeps them attached. Do this for each segment on each finger and the thumb.

11. Cut your string into five equal pieces. If using nylon rope, have an adult help singe the ends to prevent fraying.
12. Cut open each of the rubber bands and tie each of them to one of the rope pieces. Make sure the knot is very secure and is as close to the end of the rope as possible. Pull on the rubber band to ensure it is secure.
13. Thread the rope end through the top of the straws so that the rubber band goes over the top of the hand to around to the front. Give a little bit of stretch to the rubber band, but not so much that the string is pulled out of the straw. The knot should stay at the top of the finger, but a little tension is needed to ensure the hand returns to this position after pulling on the strings. Hot glue down the rubber bands.
14. The rubber bands may not line up perfectly, depending on the portion used in each knot.
15. Now, the strings at the bottom of the cardboard hand will act as tendons. Try to pull them and see how your hand works. Adjust any rubber band that slips off by pulling it up, moving it over, and regluing it.

## Reading

Voluntary muscles are one type of muscles in our body. They allow humans to walk, jump, carry things, and much more. These voluntary muscles are attached to our bones with small threadlike structures called tendons, which are a connective tissue. Ligaments and cartilage are other examples of connective tissues in our body. As their name suggests, connective tissue connects one part of the body to another and is also involved in structural support.

Ligaments are similar to tendons, but they join one bone to another bone. Tendons attach muscles to bone, helping the muscles to shorten (or contract) and move the bone. Without tendons, it would be impossible for our body to move as it does.

The wrist has two types of tendons. Flexor tendons curl the fingers and thumb, and allow the wrist to bend. Extensor tendons work to straighten and extend the fingers.

## Exercises

1. What types of muscles are connected to our bones?
2. Which type of connective tissue connects our muscles to our bones?
3. What do extensor tendons in our wrist do?
4. What do flexor tendons do?

# Lesson #2: Chemical Fingerprinting

**Overview:** Did you know that the patterns on the tips of your fingers are unique? It's true! Just like no two snowflakes are alike, no two people have the same set of fingerprints. In this experiment, you will be using a chemical reaction to generate your own set of blood-red prints.

Fingerprints are unique to each person and there is a sophisticated classification system for identifying all those lines and curves on your fingertips. This lab will teach you how to reveal your own fingerprint using a chemical reaction.

## Materials

- baking soda or sodium carbonate (washing soda)
- water
- sheet of goldenrod paper
- paper towel
- magnifying lens
- cup

## Experiment

1. Pour some water into the cup and add some baking soda (or washing soda). Swirl with your finger to mix.
2. Put your right index finger in the mixture and allow the excess water to drip off, and then roll your wet fingerprint on the goldenrod paper. This should leave a bright red fingerprint on the paper. Label it *right index*.
3. Continue the procedure for each finger on both hands to make a full set of prints. Be sure to label each fingerprint as you make it to identify which print goes to each finger. Don't forget to make prints of your thumbs!
4. Use the magnifying lens to check for fingerprint features such as whorls or loops and label them appropriately on your prints.
5. After you have identified the dominant pattern on each of your fingertips, prepare a simple chart for each hand to record the data by finger.
6. When you are finished studying your own prints, ask a volunteer to let you make prints of their fingers.

# Chemical Fingerprinting

Finger	Pattern
right index	
right middle	
right ring	
right little	
right thumb	
left index	
left middle	
left ring	
left little	
left thumb	

## Reading

Fingerprints are unique to each individual. Even identical twins have different, although similar, prints. Anyone who's watched a detective movie or read a mystery novel knows that fingerprints have a role in forensics because of their distinct nature. Fingerprints left at the scene of a crime can be compared to a database of known prints for potential matches.

Because each person's prints are unique, there is a sophisticated classification system for identifying all those lines and curves on your fingertips. A mnemonic device for remembering the three main types of fingerprint patterns is LAW: loops, arches, and whorls. Loops start and end on the same side of a finger, arches go from one side of a finger to the other, and whorls are basically circular.

Beyond basics, there are more specific classifications like radial loop, ulnar loop, plain arch, tented arch, central pocket whorl, and more! And these are only the primary classifications. Secondary classification gets down to the minutiae that are highly individualized characteristics of each print.

This experiment crosses over from biology to chemistry. The goldenrod paper is made using phenolphthalein, a chemical that turns red when exposed to materials with relatively high pH. Baking soda (sodium bicarbonate) or washing soda (sodium carbonate) are bases which have a high pH. Rolling your baking soda-covered fingers on the goldenrod paper creates a chemical reaction which produces a red fingerprint.

### **Exercises**

1. What are the three main types of patterns on fingerprints? Describe each.
2. How do fingerprints have the potential to help solve crime?
3. Why does baking soda (or washing soda) show up red on the paper?
4. What kind of pH do bases have?
5. What kind of reaction do we see when the red fingerprints show up on the paper? (a chemical reaction)

# Lesson #3: Detective Boxes

**Overview:** In addition to looking pretty neat with all those loops and whirls, your fingertips are great at multitasking. The skin on them has a ton of receptors that help us to gather a lot of information about our environment such as texture, movement, pressure, and temperature.

This experiment will test your ability to determine textures by using touch receptors. You will use shoeboxes with holes cut into them to make texture boxes. Each box will have a textured surface that you can feel, but not see. Through the receptors in your fingers, you will determine whether the surface is rough, waxy, soft, or smooth.

## Materials

- shoeboxes with lids (4)
- soup can
- pencil
- scissors
- sandpaper (1 sheet)
- wax paper (1 sheet)
- flannel fabric (1 piece)
- plastic (1 sheet)
- glue gun
- gloves
- partners

## Experiment

1. Using the soup can as a guide, draw a circle at the end of a shoebox. Then use the scissors to cut out the circle. This is the access hole for hands to reach into the box.
2. Cut a piece of sandpaper to fit the bottom of the box (a ruler might also be handy to get an exact measurement). Glue the sandpaper to the inside bottom of the shoebox. Put the lid on the box and label it as Box 1.
3. Repeat the first two steps for each of the boxes, gluing the wax paper, flannel, and plastic in boxes 2-4. Be sure to label each.
4. Now ask a partner to reach into each box, feel the texture, and describe it as rough, waxy, soft, or smooth. Record their answer. Use *undecided* if they aren't sure.
5. Once your friend has identified a texture and you have recorded their response, open the box so that you can both see what material they have evaluated. Be sure to note in your data whether your friend was correct with a *Yes* or *No*. Repeat steps 4 and 5 for each of the boxes.
6. Have your friend leave the room or look away so that you can rearrange the box lids. Then give them the gloves to wear and repeat the test using gloved hands. Record the data and compare the effectiveness of gloved hands. Does this have an impact on the touch receptors?

## Detective Boxes Data Table

Box	Description	Correct? <i>(yes or no)</i>
1		
2		
3		
4		
5		

### Reading

Our skin is made up of several layers. Epidermis is the outer layer and consists mainly of dead skin cells. The dermis is our second layer of skin and it contains things like hair follicles, blood vessels, sebaceous glands, and nerve endings. Touch receptors called mechanoreceptors are located in the dermis.

Mechanoreceptors are nerve endings (sometimes called corpuscles) and include the following

- Meissner’s endings (or Meissner’s corpuscles) respond to vibrations and light pressure, such as fluttering or stroking motions. They are located immediately below the epidermis. We have lots of these on our fingers and palm.
- Ruffini’s endings (or Ruffini corpuscles) respond to pressure. They are also sensitive to the stretching of skin and tendons.
- Merkel’s endings (or Merkel receptors) detect moderate, steady pressure and provide information to the brain about texture.
- Pacini’s endings (or Pacinian corpuscles) are embedded deep in the skin and can only detect rapid vibrations.
- Free nerve endings are the most common receptors in our skin and are essentially used in detecting pain.

The fabric of the gloves interferes with the ability of our touch receptors to function fully. Our fingertips are feeling the fabric of the gloves on their receptors, and this makes it difficult to perceive what they are touching through the gloves.

## Exercises

1. Name, in order, the three main layers of skin.
2. Which layer of skin contains the mechanoreceptors? Name two more items in this layer.
3. Name the five types of nerve endings and their specialization.



# Lesson #4: Detecting Temperature Changes

**Overview:** This experiment has two parts. For the first half, you will mix two chemicals that will produce heat and gas. The temperature receptors in your skin will be able to detect the heat. Your ears will detect the gas as it vibrates and escapes its container. In the second portion you will demonstrate a characteristic in a chemical reaction. For this experiment, it will be an endothermic reaction, which is the absorption of heat energy. This type of reaction is easy to notice because it makes things cold to touch. The chemical you will be using, ammonium nitrate, is actually used in emergency cold packs.

Thermoreceptors are the skin receptors that can detect changes in temperature. They're a type of free nerve endings (remember the ones that can sense pain?). Thermoreceptors are located in the dermis, or second layer of skin. Two types of thermoreceptors are cold receptors and warm receptors. They're found all over the body, but cold receptors being more prevalent. You have lots of these around our face, which is why it feels cold so quickly. Scarves and ear muffs are a good way to lessen the impact of our cold receptors!

## Materials

- measuring cup
- calcium chloride
- ammonium nitrate
- baggies (2, re-sealable)
- water

## Experiment

1. Put about  $\frac{1}{2}$  cup of warm water in one of the baggies.
2. Add about a third of an ounce of calcium chloride to the water. Close the baggie and start to roll around the pellets with your fingers. As they start to dissolve, the chemical also starts to increase the temperature of the water.
3. Now dispose of these ingredients down the drain. Flush with lots of running water.
4. Open the ammonium nitrate and fill its cap with pellets. Put these in the second baggie.
5. Start to pinch the ammonium nitrate through the plastic bag and check for a temperature change. Does anything happen in the absence of water?
6. Now put a small amount of water (about room temperature) into the bag. Fill it about  $\frac{1}{4}$  of the way full.
7. Hold the bottom of the bag with both hands and begin to rock it back and forth a bit. This should start to dissolve the pellets. With your hands on the water, you should start to note a temperature decrease. If this doesn't work, roll the pellets around as you did with the calcium chloride.
8. When you are finished, you can pour the contents out on to a brown spot of grass (because ammonium nitrate is a main ingredient in many fertilizers). Or if you would prefer, just empty the contents down the drain.

## Detecting Temperature Changes Data Table

Chemical	Observations: What happens when added to water?

### Reading

Thermoreceptors are the skin receptors that can detect changes in temperature. They're a type of free nerve endings (remember the ones that can sense pain?). Thermoreceptors are located in the dermis, or second layer of skin. Two types of thermoreceptors are cold receptors and warm receptors. They're found all over the body, with cold receptors being more prevalent. You have lots of these around your face, which is why it feels cold so quickly. Scarves and ear muffs are a good way to lessen the impact of our cold receptors!

Your skin has many other parts in addition to its receptors, and many play a role in temperature regulation. Some examples of these include hair, blood vessels, and sweat glands. Blood vessels and sweat glands respond to heat and cold, helping to control your body's temperature. You are probably familiar with how sweat glands help to cool you down (evaporation), but how about blood vessels? As an example, if you run around outside on a hot day, your cheeks get red because the blood vessels on your skin's surface have dilated, which brings more blood to the surface and allows the body to cool its insides a bit.

Calcium chloride splits into calcium ions and chloride ions when it is mixed with water. As this occurs, energy is released in the form of heat. This is the same heat energy you felt when holding the baggie and rubbing the pellets. Adding ammonium nitrate to water causes both its ammonium and nitrate ions to dissolve, which results in heat absorption as ionic bonds are broken. This is an endothermic reaction.

### Exercises

1. Which chemical when mixed with water was an endothermic (absorbed heat and felt cold) reaction?
2. Which chemical resulted in an exothermic reaction (gave off heat)? Why does this happen?
3. What are ways that the human body can detect temperature?

# Lesson #5: Rubber Eggs

**Overview:** Did you ever think it would be ok to bounce an egg? In science class, anything is possible! Learn how in today's experiment. After this bouncy experiment, you'll know one way to spot a chemical reaction. You'll also see how solid calcium carbonate and stinky liquid vinegar can combine to produce carbon dioxide gas.

## Materials

- hard-boiled egg
- glass or clean jar
- distilled white vinegar
- Optional: regular egg
- Optional: chicken bones

## Experiment

1. Wear your gloves and put your goggles on. No exceptions!
2. Place a hard-boiled egg into a glass or jar. Fill with enough vinegar to cover the egg and leave alone for 24 hours.
3. If doing this experiment with regular eggs or chicken bones, put each in a separate container and cover with vinegar. Let sit for 24 hours. Check again after 48 hours.

## Rubber Egg Data Table

<b>Item/Object</b>	<b>Detailed Description of Results after 24 hours</b> <i>(for hard-boiled egg ONLY, include approximately how high it bounced)</i>	<b>Detailed Description of Results after 48 hours</b> <i>(for hard-boiled egg ONLY, include approximately how high it bounced)</i>
Hard Boiled Egg		
Regular Egg (optional)		
Chicken bones (optional)		

## Reading

If you soak chicken bones in acetic acid, or distilled vinegar, you'll get rubbery bones that are soft and pliable because the vinegar reacts with the calcium in the bones. This happens with older folks when they lose more calcium than they can replace in their bones, making the bones brittle and easier to break. Scientists have discovered calcium is replaced more quickly in bodies that exercise and eat calcium rich foods, like green vegetables.

Egg shells are also made up of calcium in the form of calcium carbonate ( $\text{CaCO}_3$ ). This organic compound is also found in limestone, chalk, marble, and coral. It is classified as a base, with a pH below 7.

Vinegar contains acetic acid. Acetic acid is what gives vinegar its awful taste. It's classified as an acid, with a pH above 7.

As calcium carbonate reacts with the vinegar, and the egg shell dissolves, a chemical change occurs and carbon dioxide gas is released in the form of bubbles. These can be clearly seen as the egg shell dissolves. You will also smell vinegar when the bubbles occur, but vinegar is not being given off by the chemical reaction. Vinegar has a very low surface tension which makes that stink go everywhere.

### Exercises

1. Describe what the eggshell looked like before the reaction.
2. Describe the acetic acid
3. The product you witnessed in this chemical reaction was carbon dioxide, a colorless, odorless gas. How can you tell there really was a chemical reaction?
4. Why did the egg turn to "rubber?"

# Lesson #6: Foggy Hands

**Overview:** Skin has another function that is vital to your survival: temperature regulation. Being exposed to high temperatures causes your skin's pores to open up and release sweat onto your body. This helps cool us off by the resulting process of evaporation.

Your pores will close in extremely cold temperatures. Also, the body stops blood flowing to the skin in order to conserve heat for the important vital organs and their processes. In this lab, we study the moisture that your skin produces.

## Materials

- baggie, gallon size
- string, 12 inches long
- pencil
- clock

## Experiment

1. Record a description of how moist your hand is prior to putting it in the baggie. This is at *0 minutes*.
2. Put your hand in the baggie and use the string to close it around your wrist. No air should be able to get in or out of the baggie. Record the time for tracking purposes.
3. Check your hand every 10 minutes for a half hour. With each observation note the amount of moisture that has accumulated. Record your observations at *10 minutes*, *20 minutes*, and *30 minutes*.
4. What do you think will happen if you go outside and run around with your hand inside the bag? Try it and see if it accelerates the process.

## Foggy Hands Data Table

Time	Observation
0 minutes	
10 minutes	
20 minutes	
30 minutes	

### Reading

Sweat glands are always producing moisture on our skin, releasing it through the pores. When this moisture hits the air, it starts to evaporate – which means it changes from a liquid into a gas or vapor. This process helps to cool us down. Most of the time, we don't really notice that it's going on (unless we're really active or it's a very hot day). But by enclosing your hand in plastic, this moisture can't evaporate as it normally would. In this experiment, the bag collects and condenses it.

It is interesting to note that your body can produce up to a gallon of water in extremely hot temperatures – 110 degrees Fahrenheit and higher. This is one of the reasons it's so important to stay hydrated in extreme heat!

### Exercises

1. How is sweat released from the body through the skin?
2. How does sweat help to cool the body?
3. What did you observe at the 30 minute mark in your experiment?
4. What is evaporation and how is it different from condensation?

# Lesson #7: Finger Thermometers

**Overview:** Your fingers have receptors which perform various jobs. In addition to touch, they can detect pressure, texture, and other physical stimuli. One specialized type of receptors is called Ruffini's receptors. They are good at identifying changes in pressure and temperature...most of the time! In this experiment, we will test their ability to distinguish between hot and cold temperatures. We are actually going to try and trick your Ruffini endings. Do you think it will work?

## Materials

- Glasses (3)
- Celsius/Fahrenheit thermometer
- hands
- clock with second hand
- water, hot
- water, cold
- ice cubes (optional)
- water, room-temperature

## Experiment

1. Place the three glasses in front of you on a table. They should be in a row: left, middle and right.
2. Put hot water from the faucet into the first glass on your right. Pour very cold water from the tap into the far left glass. You can even add a couple of ice cubes if you have them available. Finally, fill the glass that is in the middle with room temperature water.
3. Now use your right hand to hold on to the glass on the right with hot water. Really spread out your fingers and wrap them around the glass. Do the same thing with your left hand and the glass filled with cold water. Be sure to check the clock and leave your hands on the glasses for exactly one minute.
4. After one minute, take your hands and put them both on the middle glass. (You may need to stack one on top of the other if your glasses are narrow). Note the temperature you feel with each hand: *hot*, *cold*, or *medium*. You can use the thermometer to record the actual water temperature.
5. Now repeat steps 1-4. This time, switch the hot and cold glasses so that you are holding the hot water with your left hand and the cold water with your right hand. Compare these results with your initial results. Do both hands respond in a similar way or is one more sensitive than the other?

## Finger Thermometers Data Table

Glass	Right Hand	Left Hand	Temperature
hot			
lukewarm			
cold			

### Reading

Your hands are designed to adapt to temperature. Touching the warm glass relaxes the muscles of your hands, increases circulation, and enhances flexibility. When your hand touches the cold glass, the cells on your skin's surface begin to contract to minimize loss of heat and your hand becomes less flexible. Then, when you grab the middle glass, your hands get a bit confused. Relatively speaking, the middle glass feels warmer to the hand that was holding the cold glass and it feels cooler to the hand that was holding the warm one. The hands are still feeling the temperature, but your brain gets confused.

Did you know that our skin does not have receptors to indicate burning hot? This sensation is actually created by three different receptors which fire at the same time: pain, cold, and warm. This explains why to some people, very hot things actually feel cold. If you could prepare a group of alternating hot and cold metal bars, touching them with your fingers would be an odd experience. Your brain will think they are too hot to touch and will tell you to pull away your hand!

### Exercises

1. Does the temperature of the middle glass feel *warmer*, *cooler*, or the *same* when you touch it with your hand that was holding the warm glass?
2. What does your hand that was touching the cold glass feel when it touches the middle glass?
3. What do you feel when both hands are on the middle glass?
4. Why do you think your hands are not the best instruments for determining temperature?
5. Which nerve endings help to detect changes in temperature?



# Lesson #8: Cooling and Heating

**Overview:** In this experiment, we will continue to explore Ruffini's endings in your skin. We also look at your body's ability to detect temperature and regulate its own temperature. You will study how the body cools and warms itself to achieve temperature equilibrium, a state of constant balance.

## Materials

- rubbing alcohol
- cotton ball
- liquid crystal thermometer strip
- glove

## Experiment

1. Position the liquid crystal sheet on the back of your hand. Give it a moment to register the temperature of your body. Record the color (or temperature reading if using a thermometer) as the base reading for your data.
2. Put some rubbing alcohol on a cotton ball. Now use the cotton ball to wipe the alcohol on the surface where you took the reading, right on the back of your hand. Quickly put the thermometer strip right back on the spot where you have put the alcohol and take another reading. Note the color and/or temperature in your records.
3. Now put the glove on your hand and run around in the yard, do some jumping jacks, or find another way to be physically active for 3-5 minutes.
4. When you have worked up a sweat, come back to the experiment area. With your hand still in the glove, put the liquid crystal thermometer on the back of your hand where you took the first reading. Record the color and/or temperature information in your data records.
5. Finally, take off the glove and observe your hand. Can you tell that your sweat glands have been working? If so, have they been very active or just a little active?

## Cooling Data Table

	Color/Temperature	Notes
room temperature		
alcohol		
exercise		

### Reading

Your body likes to keep your temperature in equilibrium, which is a state of balance. It works hard to regulate your temperature and avoid any sudden changes that could be harmful. Constant and predictable is your body's goal, and it uses your skin to help.

When you are cold, blood flow to the skin is reduced in order to help stem the loss of heat. Your hair also stands on end in an effort to trap air next to the body and help insulate it...although this doesn't work very well for most of us! This is a more effective tool against heat loss with much furrier mammals.

In order to cool you down, skin can use some of your three million sweat glands. Sweat absorbs and displaces extra heat and can also close openings to cells on the surface to avoid excess gains in heat.

Your data in the lab should have simulated the effects of body temperature in three different conditions: equilibrium, excess cold and excess heat.

### Exercises

1. What is equilibrium?
2. How does equilibrium relate to body temperature?
3. How does our body help to cool us down?

# Lesson #9: Testing Muscle Strength

**Overview:** Did you know that you have over 600 muscles in your body? They help you do everything from lifting, to walking, and even pump blood! Those would be your cardiac muscles, and they're involuntary, which means you can't control them. The ones you *can* control are voluntary, or skeletal muscles. Some groups of voluntary muscles are stronger than others because each group is designed for a different and specific function. It just makes sense that the muscle groups in our legs would need to be stronger than the ones in our toes. For this experiment, you will use a bathroom scale to test the strength of various muscle groups.

## Materials (per lab group)

- bathroom scale
- pencil
- partner

## Experiment

1. Put the scale between your knees. Now squeeze it as hard as you can and have your partner record the scale's reading.
2. Use the technique to test the muscles in the following list. Place the scale between the body parts and squeeze! Be sure to record the readings for data-keeping purposes: thighs, ankles, palms, elbows, elbow and rib cage.

## Testing Muscle Strength Data Table

<b>Muscles</b>	<b>Scale Reading</b> <i>(measure in pounds, kg, etc.)</i>
knees	
thighs	
ankles	
palms	
elbows	

### Reading

Not all muscles need to be big and powerful. Actually, muscles have various functions and uses that vary by their design. There are involuntary muscles, which we don't control. The smooth muscles in our digestive tract are involuntary, as are the thick cardiac muscles in our heart.

Our voluntary skeletal muscles aren't all big and strong, either. The muscles in our fingers are detail-oriented. They need to be fast and perform relatively small, precise movements like the ones used in writing. The design of a specific muscle group will vary depending upon the muscles' ultimate use.

Have you even had a muscle cramp? They occur when a muscle is overworked and fatigued. The muscle simply contracts and stays contracted.

### Exercises

1. What are the two main types of muscles?
2. Give an example of a muscle group that's more specific than your answers above.
3. Why aren't the muscles in our fingers big and strong like those in our arms and legs?

# Lesson #10: Inside Bones

**Overview:** Bones and muscles work together to provide a structural framework for movement. The skeleton is your body's internal supporting structure. It holds everything together. In addition to providing support, bones act as shock absorbers when you jump, fall, and run. Bones have big responsibilities, and so they must be really strong. They also need to be arranged properly for the best support and shock absorption. In this experiment, we will look at the internal arrangement of the bones holding together your body.

## Materials

- toilet paper tube
- 50-100 straws
- tape
- book

## Experiment

1. First you will explore different bone structures. Start by taking about 20 straws and arranging them randomly in your hand so that they are pointing in different directions.
2. Lay your arm and hand on a table so that the group of straws is braced against the table. Next, have a friend place a heavy book on this column of straws. What happens then it's exposed to the weight?
3. Now take 20 more straws and arrange in a circle so that they are all held vertically in your hand.
4. Repeat step 2 with these more-organized straws. Do you notice a difference? The uniformly arranged straws should be stronger than those that were randomly arranged.
5. The tubes inside your bones are more like the uniform model of straws. They also have a kind of glue that holds them in place inside the bones. Let's incorporate this idea into your model by lining the inside of the toilet paper tube with tape.
6. Place some straws inside the tube. Fill the middle of the tube with straws, making sure they are tightly packed.
7. Test your model's strength by placing a book on top of the tube. What happens when the model is exposed to the book's weight?
8. Finally, take some tape and wrap it tightly around and around the group of straws. Test this new model by placing the book on top of the tape-wrapped group of straws.
9. What happens if you use both the tube and the tape? How about if you loosely arrange the straws as you did in step 3 and tape them – does this help, or is it more important that the straws are orderly?
10. For an extra study opportunity, visit the butcher in your local grocery store and ask for the end of a beef bone. (This is sometimes packaged as a soup bone). Look at the end of the bone. What do you see? It should look like a hard outer shell of bone protecting a softer, spongy portion. Draw a picture of your observations.

## Inside Bones Data Table

Straw Bundle Type	Weight Applied	Observations

### Reading

The skeletal system is the foundation of the body's skeletal system is its bones. It also includes cartilage, ligaments, tendons, joints, and other connective tissues. Our skeletal system provides both shape and protection for our bodies. Along with the attached muscles, it forms the musculoskeletal system, which gives us locomotion – movement, but not of trains! The bones in our skeleton work together with our muscles and connective tissue to allow us to walk, jump, dance, dribble basketballs, knit scarves, and so much more.

The bones of our skeleton have a very unique composition which makes them really strong and allows them to absorb shock. This arrangement is very important to support and protect the body. In fact, there's a soft, spongy part inside our bones called cancellous bone. It has a honeycomb structure which makes our bones light, but still helps them to be very strong.

The tubes inside these honeycombed, cancellous bone tissue are called the Haversian system, and they are in part made up of collagen, but with lots of calcium and phosphorus to keep them hard and strong.

### Exercises

1. Name some of the parts that make up our skeletal system.
2. What is the smooth, hard, protective layer on the outside of bones called?
3. What is the inside spongy, porous, honeycombed bone called?
4. What is the network of tubes inside bones called?

# Lesson #11: Tendon Reflex

**Overview:** Involuntary responses are ones that you can't control, but they are usually in place to help with survival. One good example is when you touch something hot. Your hand does not take the time to send a message to your brain and then have the brain tell your hand to pull away. By then, your hand might be seriously hurt! Instead, your body immediately removes your hand in order to protect it from further harm. Today, you will test an involuntary reflex by using the tendon reflex test, which is in place because our knees are sensitive and vulnerable parts of the body.

## Materials

- knee
- partner

## Experiment

1. Sit with your legs crossed at the knee on the edge of your seat. Reach forward and see if you can feel the patellar tendon. It is right below your knee cap.
2. Ask your partner to *gently* tap the tendon with the outside edge of their hand. This will look like a careful little karate chop. If your partner gets the right spot it will be obvious. You will notice your leg kick out a little in a reflex reaction.
3. Your partner can try other spots on the tendon if reaction isn't achieved at first. If it hurts, stop right away! It's possible that you might not have a tendon response reflex. Not everyone does, and that is perfectly normal.

## Tendon Reflect Data Table

Location of Tap	Observation

### Reading

There are two main parts that make up the nervous system. The central nervous system consists of our brain and spine and the peripheral nervous system is all the nerves and other fibers that connect our limbs and organs back to the central nervous system.

The peripheral nervous system is further divided into the somatic system and the autonomic system. The somatic system sends messages from brain to limbs so that we can move our bodies, and also collects and delivers information received from our five senses. The autonomic nerves send information to our organs, blood, and other parts of the body, keeping things going that we don't have to think about but that are still very important, like breathing and digesting food. The autonomic system also controls reflexes. We're going to test it out today.

The tendon reflex is in place because the knee is such a sensitive and vulnerable part of the body. When the tendon is stretched out and bumped, your body tries to move the leg and knee out of harm's way so that it won't get hurt. As you could probably tell, it's an involuntary response that neutralizes any conscious, voluntary control that your brain has over the leg through the motor nerves.

### Exercises

1. What are the main parts of the nervous system?
2. What are the two parts of the peripheral nervous system and what are their functions?
3. Which part of the nervous system controls involuntary reflexes?



# Lesson #12: Detecting Plaque

**Overview:** The buildup of things like food and bacteria where your gums and teeth meet, and also between your teeth, is called plaque. Where plaque lives is also where the bacteria turns the sugar in your mouth into harmful acids that attack your teeth's enamel and can lead to gum disease. Regular brushing is a great way to remove plaque and keep your mouth healthy.

## Materials

- red disclosing tablets
- clear plastic cup
- mirror
- red crayon
- water

## Experiment

1. Disclosing tablets are designed to identify plaque by turning it red. Remove a pill from the packaging and put it in your mouth. Chew it up thoroughly but don't swallow it. *Be very careful not to get any of the dye on clothing or anything else that might stain. The color is very difficult to remove!*
2. Take the cup full of water and rinse out your mouth very well. Spit the water out into the sink. Check your mouth in the mirror. All of that red is plaque! Draw a picture of your mouth and use the red crayon to note where the plaque is attacking your teeth and gums.
3. You should have a total of four pills in the package. You can test other members of your family, or if you would prefer, test yourself over a period of a few days after you have had a chance to observe and identify where you should be doing a better job of tooth-brushing.

## Reading

Bacteria live in your mouth all the time – a little gross right? This is completely normal and some of the bacteria are the helpful kind. However, certain types of bacteria really latch on to the enamel of your teeth. Enamel is the protective surface that covers teeth. Enamel is made up of minerals, like calcium, and it's very durable. But unfortunately plaque isn't completely impenetrable. If bacteria isn't removed by brushing and flossing, those bad bacteria on teeth will multiply. The bacteria then start to form a sticky film called plaque. It's plaque that causes cavities. When you eat sugary foods and don't brush and floss afterward, plaque turns the sugars into acid. The acid eats away at the enamel in your teeth, creating holes in the enamel and, eventually, dreaded cavities.

When you chew the tablets, they start to dissolve and mix with your saliva. This makes a water soluble dye that affixes to the bacteria and other particles in your mouth. The dye is absorbed by the bacteria, so it holds onto it even after your mouth is rinsed. This enables you to identify the unbrushed areas in your mouth. You'll probably also find your toothbrush turns purple along with your tongue! That's where bacteria often lives besides on your teeth.

Have you ever counted your teeth? They started to appear when you were a baby – about 6 months old or so. Kids have 20 deciduous, or baby teeth. These will fall out and the adult teeth grow in to replace them. Adults usually have 32 total teeth.

## Detecting Plaque Data Table

Date/Time	How Long Did You Brush Your Teeth?	Draw a Picture of Your Mouth

### Exercises

1. Why does this experiment work at detecting plaque?
2. How can dentists and moms use this to make sure you're doing a good job brushing?
3. What is plaque, and why is it bad for you?

# Lesson #13: PTC Testing

**Overview:** Stick your tongue out and look in a mirror. What do you see? Those tiny bumps all over your tongue aren't really your taste buds. They are papillae, and most of them do contain taste buds, which are the tiny sensory organs on your tongue that allow you to taste food. More specifically, they help you to distinguish between sweet, sour, salty, and bitter flavors. It's tiny microvilli (hair-like protrusions) on the papillae that have the taste receptors which send the sweet, sour, salty, or bitter messages to the brain.

Today, we will check to see if you have a dominant or recessive gene for a distinct genetic characteristic. We'll do this by testing your reaction to the taste of a chemical called phenylthiocarbamide (or PTC, for short). The interesting thing about PTC is that some people can taste it – and generally have a very adverse reaction. However, some people can't taste it at all.

## Materials

- PTC paper
- family members

## Experiment

1. Put the PTC paper in your mouth. If you have the dominant gene, it will usually taste pretty bitter. It might also be sour or even a little sweet. If it tastes like a piece of paper, you have a recessive gene.
2. After testing your paper, be sure to note whether you are a *taster* or *non-taster*.
3. Now test at least five more people in your family and note their reactions as *tasters* or *non-tasters*. Also note their relationship to you.
4. If you have enough PTC paper, make a genetic tree of your responses. Put Mom and Dad at the center and list you and your siblings branching out beneath them. Then list both sets of grandparents above each of your parents. For an interesting visual representation, circle the names of family members who test positive and leave the negative testers uncircled.

## PTC Testing Data Table

Subject tested	Taster or Non-Taster?	Dominant or Recessive Gene?

### Reading

The gene that determines whether or not you can taste PTC is a part of your DNA (deoxyribonucleic acid). It is the genetic blueprint that you were born with and it determines everything about you: from hair color to the size of your feet. But DNA also plays an important role in how your five senses function. Colorblindness is a genetic deficiency in which a person cannot see colors or has a difficult time with distinguishing them. It can range in severity. Some people who are colorblind can't tell the difference between colors like red and green, but some see no colors at all. Everything looks like a black and white movie to them. Just like colorblindness, our taste sensitivity can vary. Maybe this explains why some people like liver and Brussels sprouts and others can't stand them!

So to relate this to our test, the ability to taste PTC comes from a gene. We know that if both of your parents can taste it, there is a high likelihood that you will be able to taste it, too. About 70%, or 7 out of 10, people can taste it. But what does it mean? In truth, not a lot. It doesn't mean you have a highly developed palate or a better sense of taste. It just means you are lucky enough to have inherited a gene that allows you to taste a disgusting, bitter chemical on a piece of paper.

### Exercises

1. What are the tiny hair-like organelles that send taste messages to your brain called?
2. What are the bumps on your tongue called?
3. What kind of trait does this experiment test?

# Lesson #14: Testing Spit Samples

**Overview:** Digestion starts in your mouth as soon as you start to chew. Your saliva is full of enzymes. They are a kind of chemical key that unlock chains of protein, fat, and starch molecules. Enzymes break these chains down into smaller molecules like sugars and amino acids.

In this experiment, we will examine how the enzymes in your mouth help to break down the starch in a cracker. You will test the cracker to confirm starch content, then put it in your mouth and chew it for a long time in order to really let the enzymes do their job. Finally, you will test the cracker for starch content and see what has happened as a result of your chewing.

## Materials

- soda crackers
- paper plates (2)
- craft stick
- iodine ( 0.5 oz. bottle)
- plastic pipette (1 mL)
- water
- latex gloves
- marker

## Experiment

1. Label the plates with the marker. One will be for the water sample and one will be for the spit sample
2. Take a cracker from the package and put it on the “water” plate. Use your thumb or a spoon to mash it up, making the pieces as small as possible.
3. Add a small amount of water with the pipette. Mix everything up with the craft stick to make a mash of cracker.
4. Now fill the pipette with iodine. When iodine comes in contact with starch, it changes in color from reddish-brown to a dark bluish-black.
5. Take the pipette and squeeze a few drops onto the cracker mash in various spots. Record what you see in your experiment data.
6. Take another cracker and chew it up for about 2 minutes. Do you notice any flavor changes as you are chewing? If so, note this. Be particularly aware of any sweet flavors.
7. Spit the mash onto the plate labeled “spit” once you have chewed for 2 minutes.
8. Use the pipette of iodine to add a few drops of iodine to the chewed mash. Note any change in color. If there is no starch, the iodine will stay reddish-brown in color. If starch is present, you will see the color change to a very dark blue-black as it did in step 2. Record what you see in your data.

## Spit Samples Data Table

Item Tested	Chewed or Not?	Observations with Iodine

### Lesson Reading

This lab gives you a good idea of what happens in digestion, which starts as soon as food enters your mouth. Actually, the process can start even before this as your body prepares for food. Have you ever had a wonderful smell make your mouth water? This is your body's way of getting ready to get to work digesting that delicious food.

Once you take a bite, the enzymes start to do their job of breaking large, more complex molecules into smaller particles. In this experiment, starch gets broken down into simple sugars that your body could easily move around and use as fuel.

There are three sets of saliva-secreting glands in your mouth. They include a gland in the back of your throat called the parotid gland, one in your lower jaw called the submandibular gland, and the sublingual gland, which is under your tongue. The three work together to secrete up to 2 liters of saliva each day.

### Exercises

1. What is the first step in the digestive process?
2. How does saliva help to digest food?
3. Name one or more of the main salivary glands and where they are located.

# Lesson #15: Mapping Your Tongue

**Overview:** The tongue has an ingenious design. Receptors responsible for getting information are separate and compartmentalized. So, different areas on the tongue actually have receptors for different types of tastes. This helps us to separate and enjoy the distinct flavors. In this experiment, you will be locating the receptors for sweet, sour, salty, and bitter on the tongue's surface.

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**Suggested Time** 30-45 minutes

**Materials** cotton swabs (4)

- cups (5)
- black tea (1 bag)
- red vinegar
- sugar
- salt
- microwave
- water
- spoons
- partner
- blindfold

## Experiment

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.
3. Label the first cup as "bitter." Put 3 ounces of water into it. Add teabag and have an adult help you to heat the water in the microwave. This will make your bitter cup. Let it sit for 5 minutes. While it is steeping, you can prepare the other cups.
4. Fill the remaining cups with 2 ounces of water each. Label each and prepare them as follows:
  - a. For the sweet cup, add two teaspoons to the warm water in one of the cups. Stir until well dissolved.
  - b. For the sour cup, add 2 ounces of red vinegar to another cup and stir well.
  - c. For the salty cup, put two teaspoons of salt into the final cup. Stir until dissolved.
  - d. The last step in cup preparation is to discard the tea bag that has been steeping in the first cup.
5. Now, put the blindfold on your partner and have them stick out their tongue. Dip the first swab into the tea. Using the diagram as a guide, swab each area one at a time: A, B, C, and D. Ask your partner to identify

the flavors as *sweet, sour, salty, bitter, or can't tell* as you swab each individual area. Record your partner's response for each area.

- Your partner should rinse out their mouth with water after testing the bitter tea. Then test each of the remaining solutions, one at a time in the same manner.

## Mapping Your Tongue Data Table

Liquid Type	Tongue Location A	Tongue Location B	Tongue Location C	Tongue Location D
bitter				
sweet				
sour				
salty				

### Reading

Humans can identify thousands of distinct tastes, but we only have four types of taste receptors. When you take a bite of something flavorful, the enzymes in your saliva start to dissolve it immediately. This solution of flavor and saliva goes to your taste buds and is then interpreted by your brain as sweet, sour, salty, or bitter.

The taste buds are located on the little bumps all over your tongue (those are called papillae). The taste buds have taste receptors which bind to the structure of certain molecules: sweet receptors recognize hydroxyl groups (OH) in sugars, sour receptors find acids (H<sup>+</sup>, such as the citric acid in a lemon), salt receptors respond to metal ions (like Na<sup>+</sup> in table salt), and bitter receptors are triggered by alkaloids. These are bases which contain nitrogen. It's interesting to note the location of the bitter taste buds – they are on the back of the tongue. Since many poisons are alkaloids, their bitter taste may actually trigger vomiting.



Anyone who's had a stuffy nose can tell you that smell plays a big role in our ability to taste. This makes sense because we know that we can only really taste the four distinct true flavors of sweet, sour, salty, and bitter. Our nose works in partnership with our tongue to allow us to identify more complex flavors.

### **Exercises**

1. How many different types of taste receptors do we have? What are they?
2. Can you still taste food when you have a stuffy nose?
3. Which taste receptors recognize the hydroxyl group?

# Lesson #16: Tasty Taste Buds

**Overview:** Did you know that your tongue can taste about 10,000 unique flavors? Our tongues take an organized approach to flavor classification by dividing tastes into the four basic categories of sweet, sour, salty, and bitter.

For this experiment, you will need a brave partner! They will be blindfolded and will be attempting to guess foods. Relying only on their sense of taste, they will try to determine what kind of foods you are giving them.

## Materials

- partner
- blindfold
- water (one cup)
- plate
- lemon
- toothpicks (2)
- sugar cube (or some sugar)
- salty cracker
- piece of dark or bitter chocolate
- pencil

## Experiment

1. (NOTE: Make sure your partner is not around for the first step!) Prepare a plate with a piece of lemon on a toothpick (minus the rind), a sugar cube, a really salty cracker, and a piece of dark chocolate, which will also be on a toothpick.
2. Blindfold your partner before they see the plate. Explain that you're going to give them food samples. Their job is to taste each sample, one at a time, and then determine whether the food is sweet, sour, salty, or bitter. After they have provided a category, see if they can tell you the specific flavor of the food. They should use the water between samples in order to rinse their mouth and prepare for the next food.
3. Record data and observations for each individual food item. Be sure to list each food, your partner's group classifications (sweet, sour, salty, or bitter) and what specific flavors that they note.

## Tasty Taste Buds Data Table

Food	Group classification	Flavors noted?

### Reading

When you put food in your mouth, saliva immediately begins to break it down. Saliva mixes with food and makes a solution, which then takes the food (and its flavor) to the taste pores. There, receptors determine the chemical structure and send this information to your brain, which then decodes and categorizes the taste. The exact nature of the secret code relayed between your taste receptors and your brain is still a mystery. Maybe someday you can help to figure out the science behind it!

Did you know that humans have about 7,500 taste buds? That's a lot compared to most chickens, which only have about 24, total. But it's a pretty small amount compared to catfish. They have over 175,000 taste buds! Can you imagine what your favorite dessert might taste like if you had that many? I wonder if it would be a good thing, or maybe too much information. Perhaps we are better off with our own perfect number of taste buds!

### Exercises

1. How does saliva help with tasting?
2. What helps to decode the chemical structure of a food so that the brain can determine its taste type?
3. Why do foods sometimes become less strong as we age?

# Lesson #17: Stethoscope

**Overview:** Stethoscopes are instruments used to amplify sounds like your heartbeat. Your doctor is trained to use a stethoscope not only to count the beats, but he or she can also hear things like your blood entering and exiting the heart and its valves opening and closing. Pretty cool!

Today you will make and test a homemade stethoscope. Even though it will be pretty simple, you should still be able to hear your heart beating and your heart pumping. You can also use it to listen to your lungs, just like your doctor does.

## Materials

- rubber hose (3, 12-inch lengths)
- “T” connector
- funnel
- stopwatch or clock with a second hand

## Experiment

1. Take two pieces of hose and work them onto the top ends of the “T” connector. Put the remaining piece of hose onto the bottom of the “T.” The tool you have made should look like a simple stethoscope, but there are no super cold metal end pieces to worry about with yours.
2. Put the funnel into the bottom hose – the one hanging from the bottom of the “T” connector. You now have a functioning stethoscope. One word of warning: **NEVER YELL INTO THE FUNNEL WHILE THE STETHOSCOPE IS ATTACHED TO SOMEONE’S EARS. THIS COULD DAMAGE EAR DRUMS!**
3. Gently insert the side tubes into your ears. Put the funnel on your chest, just to the left of your breastbone. Listen for your heartbeat. If you are in a sufficiently quiet room you may even be able to hear the opening and closing of your heart’s valves.
4. After you’ve found your heart, try moving the stethoscope to various areas of your chest and listen for different sounds made by your heart. Ask if you can listen to a friend or family member’s heart. Are the sounds made by another heart the same or different?
5. Now listen to your lungs, placing the end of the stethoscope just above and to the left of the bottom of your ribcage (Point A), to the right of the bottom of your ribcage (Point B), and just below where your ribs start (point C). Also listen in the middle of your back to the left (point D) and right of your spine (point E). In each spot, take a deep breath and listen for the sound of air entering and exiting the lungs.
6. For your data records, record how many times your heart beats in a minute while you are quiet and sitting.
7. Next, do 100 jumping jacks. Sit down immediately and check your heart. Record the number of beats per minute for jumping jacks in your data.
8. Finally, go outside and run for 3 minutes, non-stop. Then sit and immediately check your heart rate one more time. Record the beats per minute for running in your experiment data.

## Stethoscope Data Table

<b>Location Tested</b>	<b>Did You Sit Still, Do Jumping Jacks, or Run?</b>	<b>Heartrate</b> <i>(measure in seconds)</i>
<i>Point A</i>		
<i>Point B</i>		
<i>Point C</i>		
<i>Point D</i>		
<i>Point E</i>		
<i>Point A</i>		
<i>Point B</i>		
<i>Point C</i>		
<i>Point D</i>		
<i>Point E</i>		
<i>Point A</i>		
<i>Point B</i>		
<i>Point C</i>		
<i>Point D</i>		
<i>Point E</i>		

## Reading

The cardiovascular system is made up of the heart, blood, and blood vessels. Exercise creates a demand for oxygen in your muscles, which is received from work done by your heart and lungs. They get a message from your brain and start to work harder. You can see the proof of their hard work in your recorded data.

Blood circulates through the heart chambers, lungs, and body. Carbon dioxide (CO<sub>2</sub>) and oxygen (O<sub>2</sub>) are exchanged in the lungs and tissues. Contractions of the heart generate blood pressure, and heart valves prevent backflow of blood in the circulatory system.

## Exercises

1. Which body system is the heart a part of?
2. What are some of this system's jobs?
3. How many chambers does your heart have and what are they called?

# Lesson #18: Heart Rate Monitoring

**Overview:** When you exercise, your body requires more oxygen in order to burn the fuel that has been stored in your muscles. Since oxygen is moved through your body by red blood cells, exercise increases your heart rate so that the blood can be pumped through your body faster. This delivers the needed oxygen to your muscles faster. The harder you exercise, the more oxygen is needed, so your heart and blood pump even faster still.

## Materials

- stopwatch or clock with a second hand
- pencil

## Experiment

1. While sitting quietly, place your first two fingers of one hand onto the wrist of the other hand. Feel for the pulse of your radial artery. Practice taking your pulse in intervals of 6 seconds.
2. After you have had some practice with the 6-second interval, take your pulse for this amount of time and multiply it by 10. The 6-second rate times 10 is your heart rate per minute. Record each for experiment data.
3. Now stand up and do 50 jumping jacks. When done, sit down immediately and check your pulse. Again, record the 6-second pulse rate, multiply it by 10 and also record the pulse rate per minute.
4. Finally, go outside and run around as fast as you can without stopping for 3 minutes. Again, immediately sit and take your pulse. Record the 6-second rate, multiply it by 10 and get your heart rate per minute.

## Heart Rate Monitoring Data Table

<b>Activity</b>	<b>6-second pulse</b>	<b>bpm</b> <i>(6-second pulse x 10)</i>
<i>sitting</i>		

### Reading

Exercising means your muscles need more oxygen. They ask your brain to tell your heart and lungs. When your heart gets the message, it starts to beat harder. Your lungs work harder, too. Together, your heart and lungs work as a team to provide the needed oxygen supply to your muscles. You can identify that this process is occurring by your heart rate increase and more rapid breathing rate.

Did you know that your heart is about the size of your fist? It is actually a muscle, and it pumps more than a gallon of blood through your body each minute! An average heart rate is 70 beats per minute, but this can vary depending on age and fitness level. Based on 70 bpm, your heart will beat around 100,000 times per day. That's more than 36 million beats a year!

### Exercises

1. Explain how to take a pulse.
2. What units do we use to measure pulse?



# Lesson #19: What's Your Lung Capacity?

**Overview:** Did you know the right lung is slightly larger than the left? It's true! The left lung is slightly smaller to make room for the heart. Lungs are among the largest organs in your body. They are a part of the respiratory system, whose main function is gas exchange between our body's circulatory system (our blood) and the environment (more specifically, the air around us). Through respiration we receive oxygen to help fuel our bodies, and dispel carbon dioxide and other wastes.

## Materials

- 2-liter soda bottle
- black marker, permanent
- rubber hose (12" long)
- large plastic bowl
- liquid measuring cup (cups or millimeters)

## Experiment

1. Fill the measuring cup with water up to either the cup or 100 milliliter mark, depending on the measurement you're using. Pour this into the 2-liter bottle and mark the water level with a line using the black, permanent marker. Also, write a "1" next to the line.
2. Keep adding water, one cup (or 100 milliliters) at a time, marking each new 1-cup increment until you have filled the bottle with water. Cap it.
3. Put water in the bowl, filling it about half of the way full. Now flip the full (but capped) bottle of water over the bowl. Be careful to keep the opening of the bottle under water so that no water is displaced in the process.
4. Put one end of the rubber hose in the top of the bottle (which should be now under water).
5. Take a really deep breath – as deep as you can – and blow your breath out into the tube. Continue to blow until you can't push any more air into the bottle. As air goes in the bottle, it pushes an amount of water equal to its volume out and into the bowl.
6. Put the lid on the bottle and turn it over before lifting it out of the water. How much water is left in the bottle? Subtract this amount from the original amount of water in the bottle. This should be your lung capacity.
7. Record your lung capacity as, "My lung capacity is \_\_\_\_\_." If you used cups, convert this number to milliliters by multiplying by 0.24 liters per cup. For example, 19 cups would equal 4.5 liters.

## Reading

A man's lungs have a greater capacity than a woman's – it's about 6 liters for a man and 4.2 liters for a woman. And since a grown-up has a greater lung capacity than a kid, it makes sense that a 10-year old might breathe 20 times per minute when a grown-up might breathe only 12 times in a minute. A person who is 70 years old has breathed about 600,000,000 times in their life. But they have also breathed a lot of air – about 13,000,000 cubic feet. This is enough air to fill 52 blimps!

## Exercises

1. Which body system are your lungs a part of?
2. What are some other parts in this system?
3. Explain this system's major function.

# Lesson #20: Working Lung Model

**Overview:** Did you ever wonder how the air that you breathe and the food that you eat both go into your mouth, but end up in two very different places? Food and air can both enter through the mouth, but they diverge when reaching the esophagus and trachea. Food goes to the gastrointestinal tract through your esophagus and air travels to your lungs via the trachea, or windpipe.

You will be making a model of how your lungs work in this lab. It will include the trachea, lungs, and the diaphragm, which expands and contracts as it fills and empties your lungs.

## Materials

- 2-liter soda bottle, emptied and cleaned
- scissors
- razor (with adult help)
- drill (with adult help)
- "Y" valve hose connector
- balloons (3 round, 9-inch)
- #3 one-hole stopper
- hose (8-inches)
- rubber bands (2)
- petroleum jelly

## Experiment

1. Cut off the bottom of the 2-liter bottle. Ask an adult for help.
2. Take the "Y" valve and secure the two balloons to the top branches with the rubber bands.
3. Secure the stopper and use the drill to make a hole in it that's a little smaller than the diameter of the tubing.
4. Put a tiny bit of petroleum jelly on the end of the hose to make it easier to insert into the #3 stopper. Pull 6 inches of hose through the stopper and then thread the hose through the bottle's neck. Insert the stopper into the top of the bottle.
5. Put the end of the hose (that is now inside the bottle) into the base of the "Y" valve (which now has balloons on its other branches). Pull the hose through the stopper a bit. Also, pull the lungs up toward the top of the bottle.
6. Tie a knot in the third, unused balloon. Cut it in half and stretch the part with the knot over the open bottom of the soda bottle. Make sure the bottom balloon is as tight as it can be.
7. Grab the bottle with one hand, the knot at the bottom of the balloon with the other. Carefully pull the knot on the balloon down. What happens to the balloons in the bottle? Now let go of the knot and observe how this affects the balloons. Note your observations.

## Reading

Two very distinct body systems can take in materials via the same method – the mouth! Food and air can both enter the body here, but they diverge quickly, with food traveling down the esophagus to the stomach and air going down the trachea to the lungs.

In this experiment, placing a stopper in the top of the bottle and putting the stretched rubber balloon on the bottom creates an enclosed system. The tube at the top of the bottle is the only way for air to enter or exit the model's lungs. Pulling down on the balloon's knot reduces the air pressure inside the lungs. As compensation, air is pushed down into the tube to equalize the pressure. This causes the balloon lungs to expand. When you release the knot, the air pressure forces the air out of the balloons.

If you need more help with identification, the tube acts as the trachea, the balloons are the lungs, and the balloon with the knot at the bottom is the diaphragm.

## Exercises

1. Did the balloons inflate equally, and why?
2. Why is it useful to make a model of something like this?
3. Sketch your model and label its trachea, lungs, and diaphragm.

# Lesson #21: Detecting Carbon Dioxide

**Overview:** An oxygen and carbon dioxide exchange takes place in your bloodstream. When you breathe air into your lungs it brings in oxygen, which is carried from your lungs by red blood cells in your bloodstream. Cells of your body use the oxygen and carbon dioxide is produced as waste, which is carried by your blood back to your lungs. You exhale and release the CO<sub>2</sub> as waste. You will study this exchange in today's lab.

## Materials

- bromothymol blue
- straw
- resealable baggie
- ammonia
- pipette
- water
- goggles, gloves, ventilation, and adult help!

## Experiment

1. Pour about 2 ounces of water into the baggie and add two capfuls of the bromothymol blue. Close the baggie well and swish the solution around inside it gently to mix. Note the color of the solution for your data record.
2. Open the baggie a tiny bit and put the straw inside, **but DO NOT drink the solution!** *It could make you sick.* Close the bag tightly around the straw and gently blow into the solution. *Again, be careful not to suck on the straw.*
3. Watch the color of the solution closely as you continue to blow into the solution and create bubbles of carbon dioxide gas. The color will change to a sea green color and then eventually it will change to bright yellow. Note each color change in your records.
4. You can return the solution to blue by slowly adding a base – such as ammonia – to the solution in the bag. Bleach will also work. **Please ask an adult to help with this.**
5. Add one drop at a time, shaking after each addition to mix the solution. You will be able to observe when the pH starts to change back by the color of the solution. It should turn back to green and then to blue.

## Detecting CO<sub>2</sub> Data Table

Solution	Color Change	Acidic or Basic?

### Reading

Bromothymol blue will change color in a pH range from 6.0 to 7.6. It is an acid/base indicator. Its basic solution is at a pH of 7.6 or above – this is when it is blue. In acidic conditions, it will turn yellow – this is a pH of 6.0 or below. And when it's in between the two, it will be the sea green color that you observed in your baggie.

Because carbon dioxide is a little acidic, when we breathe it out into the water and bromothymol blue solution its bubbles start to lower the pH. You saw a small change in pH with the sea green color, but as you continued to exhale and add carbon dioxide, the solution became more and more acidic. This eventually resulted in a pH at or below 6.0 and a bright yellow solution.

In order to exchange oxygen with carbon dioxide in your lungs, they have over 300,000,000 teeny little air sacs called alveoli. In one minute, you breathe approximately 13 pints of air.

### Exercises

1. What is pH and how it is useful?
2. What does a yellow color indicate with bromothymol blue?
3. Is CO<sub>2</sub> acidic or basic?

# Lesson #22: Scent Matching

**Overview:** We now know that odor molecules are diffused throughout a room by the motion of air molecules, which are constantly moving and bumping into them. These tiny odor particles can get caught in our nose and dissolve into the olfactory epithelium, which is responsible for detecting odors so that your brain can interpret them. Today we'll test how well your olfactory epithelium and brain work together to distinguish between smells.

## Materials

- small containers with lids (10)
- cotton balls (10)
- lemon juice
- black coffee (1 cup)
- vanilla extract
- cinnamon oil
- soy sauce
- marker
- toothpick (optional)
- assistant

## Experiment

1. Your partner should be out of the room while you prepare this experiment.
2. Take the lids off of the containers and number the first five with a 1 through 5. Mark the other five with A through E.
3. Put a cotton ball into each container. Start with the numbered containers and add some lemon, coffee, cinnamon, soy sauce, and vanilla. Record the smell for each number for reference.
4. Fill the lettered containers with the same liquids, but not in the same order. Be sure to record the material you have used for each letter and match them to the proper number.
5. Take the closed containers to your assistant. Ask them to match the scent in the first canister with the proper lettered container without opening the container. (You can use a toothpick to gently puncture the top of the container, or you can hold the container so that odor molecules can get out, but your helper can't see inside.) Note their response – are they correct?
6. Repeat step 5 for each of the containers until they all have been matched. Then check your recorded data and see how well your assistant did with matching.

## Scent Matching Data Table

Item	# container	letter container	Correct?

### Reading

Everything here produces a distinct odor. The smells go into your nose, where they are interpreted by the tiny hair-like smell cells in your olfactory epithelium. The smell cells work together to distinguish smells and then send the interpreted information to the brain for recognition.

We previously noted that humans have an average of 10,000,000 smell cells, but they aren't all the same. You have about 20 different types, and each detects a specific type of odor. The types work together and your brain translates their signals as a unique odor.

### Exercises

1. What is the scientific name for sense of smell?
2. What is the name of the tissue which helps the brain to distinguish between smells?



# Lesson #23: Swallowing

**Overview:** Peristalsis is the wavelike movement of muscles that move food through your gastrointestinal tract. The process of digestion begins with chewing and mixing the food with saliva. When you swallow, the epiglottis closes up to keep food from going into your respiratory system and the hunk of chewed food (called bolus) goes into your esophagus – this is the tube that runs from your mouth to your stomach. Since the esophagus is so skinny, the muscles along it must expand and contract in order to move food down. In this activity we will examine that process.

## Materials

- several different balls the size of a tennis ball or smaller (and including a tennis ball)
- pair of old nylon stockings
- scissors

## Experiment

1. Cut away the control top portion of the nylons and remove the toe part as well (have an adult help you, if needed). You should now have a long piece of nylon.
2. Put the tennis ball in one end of the nylon “esophagus.”
3. Start using both hands to move the ball down the nylon tube until it arrives at the other end.

## Swallowing Data Table

Item/Object	How Long Did It Take to Make It Through the GI Tract? <i>(measure in seconds)</i>

### Reading

The esophagus is lined with muscles that work in waves, expanding and contracting to move food along it down into the stomach. These are very strong muscles: even if you ate upside down they would work!

In the grand scheme of the digestion process, the role of the esophagus is important, but relatively short. It takes about 10 seconds to move food from the mouth to the stomach, but the entire process of digestion can take up to 2 and a half days to finish!

### Exercises

1. What is the tube called that connects the mouth and stomach?
2. What is the process called that moves food along the digestive tract and how does it work?
3. How long is food in the esophagus?

# Lesson #24: Diffusion

**Overview:** Everything living produces some sort of odor. Flowers use them to entice bees to pollinate them. We know that the tastes of foods are enhanced by the way that they smell. As humans, each of us even has own unique odor. In this lab, we look at the diffusion of scents. They start in one place, but often end up spread around the room and can be detected by many people.

## Materials

- onion
- lemon
- ground cinnamon
- garlic (fresh, one clove)
- garlic press
- coffee grounds (fresh)
- kitchen knife (with adult help)
- cutting board
- fan (variable-speed)
- stopwatch or clock with a second hand
- assistants

## Experiment

1. Start in a room big enough so that you can prepare the foods at one end and your friends or family members can be at the other end, but positioned so they can't see what you're doing.
2. On a new sheet of paper, create a map of the room showing the locations of your partners, the source of the odor, and the fan (which will help with the scent diffusion). Create a new map for each smell. This will be your data table as well.
3. Turn on the fan and begin with the onion. Ask an adult to help you with cutting the onion into several small pieces. Be sure to hold the chopped pieces up in front of the fan. Ask your partners to raise their hands when they smell the onion. If they don't smell it, they can leave their hands down.
4. Note on the onion map where its smell is detected. Indicate with a line the farthest area where the onion is smelled. This is its leading edge.
5. Check in with your partners once per minute for five minutes. Ask them to raise their hands and repeat the process of noting the areas where the smell is detected. Each time you check, draw a line to indicate the farthest area the smell reaches. This will give you an idea of how fast and how far the smell diffused.
6. Repeat steps 3 and 4 with each item: cut and smash the lemon and press the garlic.

## Reading

Many factors affect how quickly odors diffuse. First, the air is constantly moving. As the air molecules in the room are colliding with each other (and with the odor molecules) they help to move the smells farther through the room. Second, the fan makes a huge difference. It accelerates the natural process of air and odor molecules and moves them much farther and faster than they would go otherwise. Finally, the air temperature plays an important role. If the temperature is higher, the air and odor molecules will move faster.

As humans, we can boast about 10,000,000 smell cells in our noses. This seems pretty impressive...unless you compare us to canines. Dogs have more than 200,000,000 smelling cells in their nasal cavities!

## Exercises

1. Which odors travel the farthest?
2. Which ones travel the fastest?
3. Why do we use the fan?
4. Does air temperature matter?

# Lesson #25: Consuming Oxygen

**Overview:** This experiment not only explains how your body uses oxygen, but it is also an experiment in air pressure circles – bonus! You will be putting a dime in a tart pan that has a bit of water in it. Then you will put a lit candle next to the dime and put a glass over the candle with the glass's edge on the dime. Once all of the air inside the glass is used up by the candle, the dime will be easy to pick up without even getting your fingers wet!

## Materials

- aluminum tart pan
- votive candle
- matches
- drinking glass, (clear, 12 or 16 oz.)
- dime
- water
- goggles
- Adult supervision!

## Experiment

1. Pour about  $\frac{1}{4}$  inch of water in the pan and place the dime right in the middle.
2. Position the candle next to the dime and ask an adult to light it for you
3. Put the drinking glass over the candle with its edge resting on the dime. Watch closely to observe what happens.
4. Once the water is inside the glass, you can carefully remove the dime from under its edge. If done properly, the water will stay in the glass.

## Consuming Oxygen Data Table

<b>Trial Number</b>	<b>How Long Did the Candle Burn?</b> <i>(measure in seconds)</i>	<b>How High Did the Water Rise?</b> <i>(measure in inches or cm)</i>

### Reading

This lab serves to illustrate that oxygen is consumable. It's the same thing that happens inside your body, but at a much slower rate than what you witnessed with the candle. Your lungs contain about 1,490 miles (2,400 km) of air passages to help absorb oxygen. If they could be spread out flat, an average set of lungs have a surface area of approximately 650 square feet. The sheer size of this system gives you the chance to absorb all the oxygen that your body needs.

When you put the glass over the candle, you create a closed system. The candle only had the gas trapped inside the air beneath the glass to burn. As the candle burned, the gases in the glass burned as well. They were transformed from a state of gas to a very compact solid state that stuck to the wick of the candle (this is why the wick gets black when a candle burns).

An important thing to note is that as the air was removed, the pressure inside the glass was reduced. Lower air pressure inside your closed system created an imbalance with the regular air pressure on the outside of the glass. Since there was more pressure on the outside, the water was pushed inside the glass. The dime helped to make a gateway for the water to be more easily pushed into the glass.

## Exercises

1. What do we mean when we say that oxygen is consumable?
2. What is the difference between an open and a closed system?
3. Where is the higher pressure in this experiment?
4. Why does water rise inside the glass?

# Lesson #26: Eye Balloon

**Overview:** In this lab, we are going to make an eyeball model using a balloon. This experiment should give you a better idea of how your eyes work. The way your brain actually sees things is still a mystery, but using the balloon we can get a good working model of how light gets to your brain.

## Materials

- biconvex plastic lens
- round balloon, white, 9 inches
- assistant
- votive candle
- black marker
- book of matches
- metric ruler
- **Adult Supervision!**

## Experiment

1. Blow up the balloon until it is about the size of a grapefruit. If it's difficult to inflate, stretch the material a few times or ask an adult to help you.
2. You will need an extra set of hands for this portion. Ask your partner to hold the neck of the balloon closed to keep the air in while you insert the lens into the opening. The lens will need to be inserted perpendicular to the balloon's neck. It will prevent any air from escaping once it's in place. Like your eye, light will enter through the lens and travel toward the back of the balloon.
3. Hold the balloon so that the lens is pointing toward you. Take the lens between your thumb and index finger. Look into the lens into the balloon. You should have a clear view of the inside. Start to twist the balloon a little and notice that the neck gets smaller like your pupils do when exposed to light. Practice opening and closing the balloon's "pupil."
4. Have an adult help you put the candle on the table and light it. Turn out the lights.
5. Put the balloon about 20 to 30 centimeters away from the candle with the lens pointed toward it. The balloon should be between you and the candle. You should see a projection of the candle's flame on the back of the balloon's surface. Move the balloon back and forth in order to better focus the image on the back of the balloon and then proceed with data collection.
6. Describe the image you see on the back of the balloon. How is it different from the flame you see with your eyes? Draw a picture of how the flame looks.
7. The focal length is the distance from the flame to the image on the balloon. Measure this distance and record it.
8. What happens if you lightly push down on the top of the balloon? Does this affect the image? You are experimenting with the affect caused by near-sightedness.
9. To approximate a farsighted eye, gently push in the front and back of the balloon to make it taller. How does this change what you see?



## Eye Balloon Data Table

Draw a picture of how the flame looks to you.	
Record the focal length from flame to the image.	
What happens to the image when you push down on the top of the balloon?	
What do you see when you push on the front and back of the balloon to make it taller?	

### Reading

First we'll discuss the part of the balloon that relate to parts of your eye. The white portion of the balloon represents your sclera, which you may have already guessed is also the white part of your eye. It is actually a coating made of protein that covers the various muscles in your eye and holds everything together.

Of course, the lens you inserted represents the actual lens in your eye. The muscles surrounding the lens are called ciliary muscles, and they are represented by the rubber neck of your balloon. The ciliary muscles help to control the amount of light entering your eyes.

The retina is in the back of your eye, which is represented by the inside back of your balloon. The retina supports your rods and cones. They collect information about light and color and send it to your brain.

### Exercises

1. How does your eye work like a camera?
2. How can you tell if a lens is double convex?

3. What is the difference between convex and concave?
4. Can you give an example of an everyday object that has both a convex and a concave side?
5. How can you change the balloon to make it like a near-sighted eye?
6. How can you change the balloon to make it like a far-sighted eye?

# Lesson #27: Water Lens

**Overview:** Waves of light enter your eyes through the pupil, which is the small black dot right in the center of your colored iris. Your lens bends and focuses the light that enters your eye. In this experiment, we will study this process of bending light and we will look at the difference between concave and convex lenses.

## Materials

- washer (3/8 inch inside diameter)
- microscope slide
- petroleum jelly (or lip balm)
- newsprint with small type
- pipette (1 mL) or eyedropper or spoon
- pen
- paper towel
- water

## Experiment

1. Apply a little petroleum jelly on the washer's flat side. NOTE: Washers have flat and rounded sides, so be sure you are putting the petroleum jelly on the flat side of the washer.
2. Put the washer, petroleum jelly side down, on the middle of the microscope slide. Twist the washer a bit to seat it on the slide and make a seal. This should keep the water in place.
3. Put the washer and slide on the newsprint.
4. Fill the pipette with water.
5. Use the pipette to slowly place water in the washer. Fill the washer until the water makes a domed shape. You have just made a convex lens!
6. Find a letter *e* on the newspaper and put the lens over it. Draw a diagram of what the *e* looks like through the convex lens.
7. Now use the pipette to remove water from the washer (or you can absorb some with a paper towel). Your goal is to create a dip in the surface of the water. Now find the same *e* and place your new concave lens over the letter. Draw a picture of what the *e* looks like through the new lens.

## Water Lens Data Table

<b>Water Lens Type</b> <i>(concave or convex)</i>	<b>Draw a Diagram of the Lens</b>	<b>Draw a Diagram of the Newsprint</b>

### Reading

You can see that a convex lens bends outward and a concave lens bends inward. What does this do to light?

In a convex lens, the domed surface means that if light waves come in through the flat bottom surface, they will be spread out, or refracted, as they exit the curved portion of the lens. But since a concave lens dips inward it creates the opposite effect. When light waves exit the concave surface, they are brought together. This makes images appear smaller.

The lens does all the focusing work, but it is actually the shape of the eye that determines what you see. If you have a tall, oblong eye, you are far-sighted. And conversely, if your eyes are short and fat, you are near-sighted. In either case, the lenses are functioning properly but the actual shape of the eye needs a slight adjustment.

### Exercises

1. What are the two main types of lenses?
2. How are the two main types of lenses shaped?
3. How do the two main types of lenses work?

# Lesson #28: Disappearing Frog

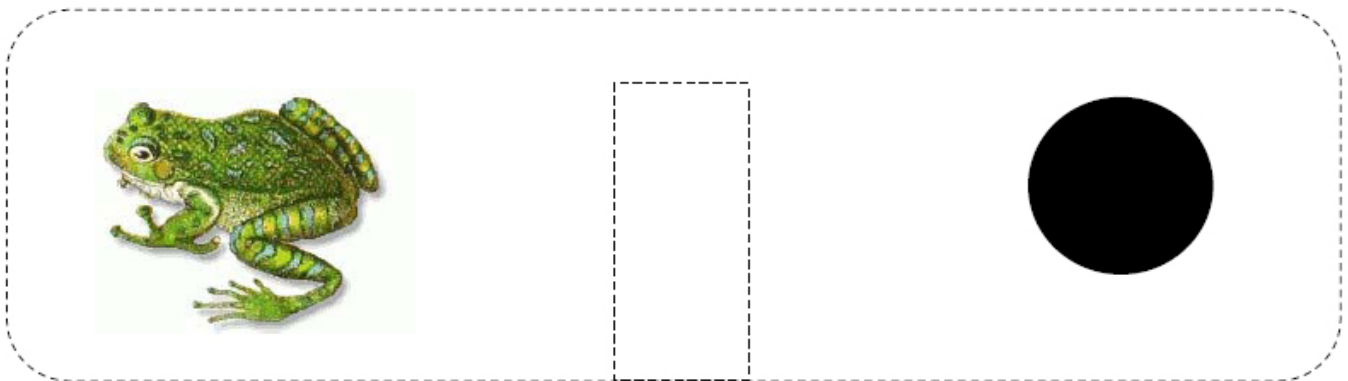
**Overview** Your optic nerve can be thought of as a data cord that is plugged in to each eye and connects them to your brain. The area where the nerve connects to the back of your eye creates a blind spot. There are no receptors in this area at all and if something is in that area, you won't be able to see it. This experiment locates your blind spot.

## Materials

- frog and dot printout
- meter stick
- scrap piece of cardboard

## Experiment

1. Print out the frog and dot and remove the dotted portion. Attach it to the piece of cardboard, which should have a matching portion removed. You can place the paper and cardboard on the meter stick at the notched area.
2. Now to locate blind spots. First, close your left eye. Look at the frog with your right eye. Can you see the dot and the frog? You should be able to see both at this point, but concentrate on the frog. Now *slowly* move the stick toward you so that the frog is coming toward your eye. Pay attention and stop when the dot disappears from your peripheral vision. At this point, the light hitting the dot and reflecting back toward your eye is hitting the blind spot at the back of your right eyeball, so you can't see it. Record how far your eye is from the card for your right eye.
3. Continue to move the stick toward your face and at some point you will notice that you are able to see the dot again. Keep moving the stick forward and back. What happens to the dot?
4. Repeat steps 2 and 3 with your left eye, keeping your right eye closed. This time, stare at the dot and watch for the frog to disappear. Move the paper on the stick back and forth *slowly* until you notice the frog disappears. You have found the blind spot for your left eye. Be sure to note the distance the paper is from your eye.



## Disappearing Frog Data Table

Student Name	Right or Left Eye?	Distance from Eye to Frog

### Reading

Cones and rods turn the light that enters the eye into images that are transmitted to the brain. Our eyes have a blind spot where the optic nerve connects to the back of the eye because there are no light receptors there. Relate the structures of the eye to their functions.

There are no light receptors in the area of your eye where the optic nerve attaches to your eyeball. This is your blind spot and if an image is in this spot, the light reflected off of it doesn't get perceived by your eye.

### Exercises

1. What did you notice about the vision of the student and the blind spot that you measured?
2. Why do you think it's important to know where your blind spot is?

# Lesson #29: Visual Reflex

**Overview:** Voluntary nerves are the ones that are under our direct control. Others, called involuntary nerves, are under the control of our brains and create involuntary reactions.

## Materials

- ruler
- assistant
- pen

## Experiment

1. You will begin by testing your visual reflexes with the help of an assistant.
2. Hold your right elbow at your waist. Position your arm so that it is parallel to the floor. Make a space of about an inch by holding your thumb and forefinger apart. Ask your assistant to hold the ruler vertically, above your thumb and finger.
3. Your job is to focus on the ruler. Your partner will unexpectedly release it so that it begins to fall. You will attempt to catch the ruler as soon as you possibly can.
4. Repeat the experiment 5 times, recording the time it takes to catch the ruler each time for your data. Use the times you record to find your average time.
5. Try this experiment with additional people. Find the average reaction speed of each person and the average speed of the group as a whole.

## Visual Reflex Data Table

<b>Trial number</b>	<b>Ruler Mark</b>
1	
2	
3	
4	
5	
<b>AVERAGE:</b> <i>(total marks/total trials)</i>	

### Reading

This experiment is an example of a voluntary response. Your eyes see the ruler moving and tell your brain, which then tells your fingers to close quickly. This all happens very fast, but involuntary reflexes can be much faster! You may notice in this activity that the ruler falls over half of the way through your fingers before you can stop it. This is partly because of the communication from eyes to brain to fingers. Although the nerves transmit very quickly, the transmission time can still take a little while.

There are two separate systems at work here: the central nervous system is your brain and spinal column and the longer nerves branching out from the spinal cord to every part of your body is the peripheral nervous system. They work in conjunction to coordinate your actions.

If you lines up all of your nerves, end to end, they would stretch for miles and miles: an average length is about 47 miles of nerves. The longest is the sciatic nerve. It goes from the bottom of your spine to the bottom of your foot.

### Exercises

1. What is the voluntary response in this experiment?
2. What is an involuntary response in your body? Give an example.



# Lesson #30: Camera Eyes

**Overview:** Your eyes have two different light receptors located on the back of the eyeball. These are the rods, which see black, white and grays, and the cones, which see color. In order to adapt to the dark, our eyes make a chemical called visual purple. This helps the rods to see and transmit what you see in situations where there is little light.

Your pupils also increase in diameter in the darkness. This allows for a slight increase in the amount of light entering your eye. This combination of visual purple and more light makes it possible for you to see in darker situations.

## Materials

- dark room
- light switch
- partner
- pencil

## Experiment

1. Turn out the light in a darkened room and give your eyes about 5 minutes to get used to the darkness.
2. After your eyes have had a chance to acclimate to the low-light conditions, it's time to get to work. Try to draw a picture of your assistant's eye. Pay particular attention to how the pupil looks in the darkness.
3. Now turn on the light while still observing your partner's eye. What happens to their pupil?
4. Draw another picture of your partner's eye with the lights on. Again, pay special attention to the diameter pupil of the eye.
5. Complete the data table by trying different lighting conditions.

## Camera Eyes Data Table

Light Conditions	Draw a Diagram of the Eye

### Reading

As you flip the light switch on, your partner's brain realizes that there is a lot of light entering the rods and cones, so it restricts the size of the opening (your partner's pupil) in order to limit the light. You might notice this on a sunny day if you go from a dark movie theater into the bright sun. It can actually hurt for moment, and makes you squint until your eyes have a chance to adjust to the brightness by reducing the size of your pupils.

### Exercises

1. How does the pupil adapt to light conditions?
2. What are the two special photoreceptors called and where are they located?
3. Which photoreceptor is used to help us see in the dark?

# Lesson #31: Human Levers

**Overview:** Levers are classified into three types: first-class, second-class, or third-class. Their class is identified by the location of the load, the force moving the load, and the fulcrum. In this activity, you will learn about the types of levers and then use your body to make each type.

## Materials

- can of soup
- meter stick
- rubber band
- lemon

## Experiment

1. Use the rubber band to attach the lemon to one end of the meter stick. Wrap the rubber band around so that you can easily slide the lemon down to adjust its position.
2. In a *first-class lever*, the fulcrum is in the middle. The load and effort are on opposite sides with the fulcrum between them. A familiar example of a first-class lever is a seesaw. To make one, place the soup can (fulcrum) in the middle and the lemon on one end.
3. A second-class lever has the fulcrum on one end, the load in the middle, and the force on the end opposite the fulcrum. A wheelbarrow is a good example of a second-class lever. To make one, put the soup can at one end of the meter stick with the lemon in the middle. Lift the other end of the meter stick for the effort.
4. Lastly, a third-class lever has a fulcrum on one end and the load on the opposite end. The force is applied in the middle in this type of lever. A golf club is an example of a third-class lever. To make one, push the soup can to the end and lift in the middle of the meter stick.

## Reading

Your head moving up and down on your spine is an example of a first-class lever. Your neck joint in the middle is the fulcrum, with load and effort on either side. In this example, load and effort switch depending on whether you are moving your head up or down.

Standing on tiptoe is an example of a second-class lever where your toes are the fulcrum. The effort, or force, is in your heels – they are lifting your body up. And the resistance is located between your toes and heels.

This leaves us with bicep curls, which are an example of a third-class lever. Your elbow serves as the fulcrum, the bicep is the force, and the weight in your hand on the end is the load.

Just for fun, did you know your knee is the largest joint in your whole body? It connects your femur, the largest bone, to the bones of your lower leg. Your smallest joints are the anvil, hammer, and stirrup in your inner ear.



# Lesson #32: Sound Speed

**Overview:** Sound has the ability to travel through the states of matter: solids, liquids, and gases. Generally, solids are the densest, liquids are next, and gases are the least dense. In this experiment we will study the movement of sound through these three states to see if density affects what we hear.

## Materials

- 3 baggies (re-sealable)
- sand
- water
- air
- desktop
- spoon
- partner

## Experiment

1. Fill each bag two-thirds of the way full with each material. You should have one bag with sand, one with water, and one with air. Seal each baggie well.
2. Put the baggies on the desk or on a table. Note the density of the materials. Which is *most dense*, *medium*, and *least dense*?
3. Place your ear down on the first baggie that is filled with sand. Have your partner use the spoon to tap the table. Listen for the sound through the bag of sand.
4. Repeat step 3 with the baggie full of water and then the bag of air. Compare what you hear through each state of matter. Rank the tapping you hear through the solid, liquid and gas in order from *loudest (3)*, to *medium (2)*, to *quietest (1)*.
5. When you have completed the tapping portion of the experiment, hold the bag of sand up to your ear. Have your partner speak to you through the baggie.
6. Repeat step 5 with the bag of water and again with the baggie of air. Note the clarity of the speech you hear through each bag. Rank each bag from *loudest (3)*, to *medium (2)*, to *quietest (1)*.

## Sound Speed Data Table

<b>Trial</b>	<b>Solid</b> <i>(1 = quiet, 2 = loud)</i>	<b>Liquid</b> <i>(1 = quiet, 2 = loud)</i>	<b>Gas</b> <i>(1 = quiet, 2 = loud)</i>
spoon			
talking			

### Reading

Sound is made by waves travelling through the air. They pass their energy along to the matter through which they are traveling. But now you know that sound doesn't just travel through the air. Molecules in water are closer together than air molecules, which makes it much easier for them to bump into one another. So the speed that sounds travel through liquid is actually faster than it travels through the air, and the sounds travel further as well. Sound travels fastest of all in solids because the molecules in this state of matter are very densely packed together. Solids pass sound much farther and at much greater speeds. If there is no matter to bounce their energy along, sound waves can't really form. So once you leave earth's atmosphere, there isn't any sound!

### Exercises

1. What is density?
2. Put these in their general order of density: liquid, gas, solid.
3. Which material passes sound waves along farther and faster?

# Lesson #33: Sound Matching

**Overview:** You know that sound comes from vibration of sound waves as they travel through materials. These vibrations are picked up by the pinna (external part of the ears). Then the vibrations vibrate your tympanic membrane, which in turn vibrates the ossicles and then the cochlea. The cochlea sends information through the auditory nerve and sends it to the brain, which recognizes it as sound. In this lab, you will test your ability to sort and match different sounds.

## Materials

- film canisters (10)
- beans
- rice
- sawdust (or pencil shavings)
- paperclips
- pennies
- marker
- assistant

## Experiment

1. Take the caps off the canisters. Number half of them 1 to 5 and mark the others with A through E.
2. Prepare your experiment while your partner is out of the room. Fill five of the numbered containers with one of the materials. Note which canister contains each material for data records.
3. Next, fill the lettered containers. Be sure to record which container contains which material for reference.
4. When the contents have been noted and the lids all replaced, bring your partner into the room. Ask them to match the sound of the item in the first canister with one of the lettered containers. They can shake, roll, and even drop the containers, but they can't take off the lid. Note the answer they give.
5. Repeat step 4 for the rest of the numbered containers. Remember to record the responses. When the canisters have all been matched, take off the lids and see how well they did.

## Sound Matching Data Table

Item/Object	Can #	Can Letter	Correct?

### Reading

Objects produce distinct sounds when they vibrate. These differences can sometimes be distinguished by your ears. If your partner has good ears, listening closely and then correctly matching the contents was probably an easy task.

Now to share a little more about the cochlea: You know it ultimately receives sounds and sends signals to the brain. It is a small organ shaped like a spiral. It's filled with fluid and tiny cells which are shaped like hairs. These hair-like cells convert the vibrations from sound into signals that can travel the auditory nerve up to the brain. The tiny cells are quite sensitive. They can actually be damaged by extremely loud noises, so remember to protect them with earplugs if you will be exposed to very loud sounds.

Did you know that the tiniest bones in your body are found in your ear? They are called ossicles, and include the hammer, anvil, and stirrup. They are located just behind your eardrum and collect the vibrations that come into the ear canal and hit your ear drum. When your ear drum begins to vibrate, the tiny bones vibrate as well. This causes your cochlea to vibrate as well, and it sends a signal to your brain for it to interpret.

### Exercises

1. What are the tiny bones in the ear called?
2. Name some other parts of the ear.



# Lesson #34: Sound Whackers

**Overview:** Have you ever held a ruler over the edge of a desk or table and whacked the end of it? If so, you would notice a funny sound. This sound changes if you change the length of the ruler that is hanging over the edge. The sound you hear is made by the ruler's vibrations.

## Materials

- desk (or table, or countertop)
- metric ruler

## Experiment

1. Place the ruler on the desk at the 20 centimeter mark. Hold the portion of the ruler that's still on the desk down very firmly with one hand. Press down the portion of the ruler hanging off the desk with the other hand. Now let it go. The ruler should begin to vibrate up and down while producing a strange sound.
2. Now rearrange the ruler so that it is placed at the 15 centimeter mark and give it a thump. What happens to the pitch this time? Is it higher or lower now that the overhanging portion is shorter?
3. Make sure you try the ruler at 5 centimeters, 10 centimeters, 15 centimeters, 20 centimeters, and 25 centimeters. Listen each time and place the lengths in order from highest to lowest pitch.
4. Finally, put the ruler at the 25 centimeter mark, with just 5 centimeters on the table and the rest hanging over the edge. Give it a whack and while it's vibrating, slide the ruler back across the edge of the table to make the overhanging portion shorter and shorter. What happens to the sound?

## Sound Whackers Data Table

<b>Ruler length</b>	<b>Pitch</b> <i>(1 is highest, 10 is lowest)</i>

### Reading

In this lab, we begin to learn about sound. You know it is collected and deciphered by your ears, but did you also know that all sound is made when something vibrates? It could be a guitar string, vocal chords in your throat, or a ruler that is hanging over the edge of the desk: Vibrations make sound.

The overhanging portion of the ruler is the portion allowed to vibrate. This determines the sound's pitch. When a short piece is hanging over the edge, a high pitch is made. And when the length is longer, the pitch is lower. This is what happens with all vibrating objects and is a function of their wavelengths.

### Exercises

1. How is sound made?
2. How do you change the pitch of the ruler?

# Lesson #35: Big Ears

**Overview:** How do you think animals know we're around long before they see us? Sure, most have a powerful sense of smell, but they can also hear us first. In this activity, we are going to simulate enhanced tympanic membranes (or ear drums) by attaching Styrofoam cups to your ears. This will increase the number of sound waves your ears are able to capture.

## Materials

- Styrofoam cups (2, small)
- Styrofoam cups,(2, large)
- scissors
- kitchen timer

## Experiment

1. Set the timer and put it on a table or desk. Walk about 6 feet away and face the timer. Listen for the ticking sound. Now, turn your back on the clock so that you are facing the other direction. How has your ability to hear the ticking changed? We can increase the sounds you hear by using the cups.
2. Get an adult to help with cutting the cups. They will hold one of the smaller cups with one hand and make a cut about an inch (3 cm) from the rim toward the bottom of the cup.
3. Draw a circle at the end of the cut that is about the size of your ear where it attaches to your head. Cut out the circle.
4. Repeat steps 2 and 3 with the other 12 oz. cup. Carefully put them on your ears with their openings pointing forward. You have just added to the size of your ears and they should be able to collect more sound vibrations. Try listening to the timer now with the cups on your ears.
5. Now repeat steps 2 through 4 with the larger cups. Set the timer one more time and listen to the timer. Compare what you hear with what you heard with your unenhanced ears, and what you hear with the 12 oz. ears.
6. On a scale of 0-10, how much did the cups improve what you were able to hear? Note where you would place both the 12 oz. cups and the 32 oz. cups on the scale if 0 is the starting point equal to what you can hear with your own ears.

## Big Ears Data Table

Cup Size	Did One Ear or Both Ears Have Cups?	How Did You Hear? <i>(Scale of 0 - 10)</i>

### Reading

Hearing is based on movement. The initial process involves the actual waves coming toward your ear, which are funneled inside to your tympanic membrane.

In this experiment we are going to focus on the initial funneling process. This is done by the visible, external part of your ear, known as the pinna. By making the pinna larger, you also increased their ability to pick up sound vibrations. This enabled you to hear much more, and at louder levels.

The pinna also help to determine the direction from which sound is coming. If a sound is coming from the left, your left ear hears it a little bit before the right. This lets your brain know where the sound originates.

### Exercises

1. Which part of the ear is this experiment testing?
2. What happens when you change your variable in this experiment?
3. Did this experiment change your ability to detect which direction a sound came from?

# Lesson #36: Nerve Tester

**Overview:** Our sense of touch provides us with information that helps us to process and explore our world. Nerves play an important part in the sense of touch by being the wires that carry signals from the skin to the brain. But the body has a plan in place so that our brains don't get overwhelmed with too much information. This plan is a lot like a blueprint for wiring a house. Just like a house has light switches and electrical outlets in strategic locations, our bodies have touch receptors of various numbers based on their location. In this lab, we will explore an arm to determine where the highest concentrations of nerves are in that limb.

## Materials

- paper clip, large
- ruler
- partner

## Experiment

1. Unfold a paperclip so that it has two open ends, forming a "U" shape. The ends should be about a centimeter apart. Measure it with your ruler to check.
2. Have your partner uncover their arm up to the shoulder. They should place this arm on the table, palm up, but it is also important that they face away from you. They shouldn't be able to see the test.
3. GENTLY touch one or both of the open paperclip ends to your partner's fingertip. Ask your partner to determine how many points you used to touch them (one or two). Then record their response as (Y) for a correct answer or (N) for incorrect.
4. Continue testing based on the numbered points in the diagram. Randomly vary the points used to touch your subject's skin, recording their Y (correct) or N (incorrect) response for each individual area.
5. Repeat steps 3 and 4, with the paperclip ends separated at a distance of 3 cm, 5 cm, and 10 cm.
6. Your turn! Switch places and have your partner test you and record your responses.
7. Finally, use the diagram and your data to design a map of nerve concentrations in the arm and hand. What are some of the advantages of this nerve placement?

## Nerve Tester Data Table

Location	1 cm - correct?	3 cm - correct?	5 cm - correct?	10 cm - correct?

### Reading

Endings are nerves are located so that we can use them to collect data. The highest concentrations of nerves are in our hands, feet and mouths. We use our hands to gather a lot of data, our feet for moving around, and our mouths for speaking. Luckily, the areas of our bodies that are more likely to be bumped and the ones we use to help protect ourselves have fewer nerve endings. Areas of particularly low concentration include our backs, rear ends, and arms.

Our tongues have the highest nerve concentration of all. In fact, nerve mapping researchers have learned that over half of our brain's sensory nerves are connected to our tongues. It makes sense when you realize that we taste, talk, and feel with this relatively small organ. It really needs to connect to so many places in the brain!

### Exercises

1. Where is the highest concentration of nerve endings in the body?
2. What are nerve ends used for?
3. Where do you think the least amount of nerve ends should be in the body?

# Lesson #37: All About Kidneys

**Overview:** Your kidneys remove waste material, minerals, and fluids from your blood and put it in your urine. Although urine is sterile, it has hundreds of different kinds of wastes from the body. All sorts of things affect what is in your urine, including last night's dinner, how much water you drink, what you do for exercise, and how well your kidneys work in the first place. This experiment will show you how the kidneys work to keep your body in top shape.

## Materials

- 1 liter of water per student
- 1 can of soda per student
- 1 sports drink, like Gatorade, per student
- Red food dye
- Chalk (or a handful of sand)
- Coffee filter or cheesecloth
- pH paper strips
- Disposable cups
- Clean glass jar
- Rubber band
- Measuring cups

If you are doing the optional Third Bonus Experiment:

- solution your teacher has prepared for you
- pipe cleaners
- cleaned out jar or bottle (pickle, jam, or mayo jar)
- water
- borax

## Experiment

### First Experiment: How Quickly Do the Kidneys Process Fluids?

1. Drink a liter of water quickly (in less than five minutes).
2. Wait 20 minutes (you can start on the second part of this lab while you wait) and then collect your urine in a disposable cup in the bathroom and use a pH testing strip to test the pH by dipping it in the cup.
3. Repeat four times so that you have four samples collected 20 minutes apart.
4. Repeat steps 1-3 for two different liquids, such as a sports drink and a soda.
5. Complete the data table for all three liquids.

## **Second Experiment: Kidney Filtration**

6. Crush a piece of chalk and place it in a clean glass jar. (You can alternatively use a handful of sand from the playground if you don't have chalk.)
7. Fill the jar partway with water.
8. Add a few drops of red food coloring to the water.
9. The chalk (or sand) represents toxins in the blood. The water represents the blood.
10. Place a coffee filter (or cheesecloth) on top of the jar and secure with a rubber band. This coffee filter is your kidney.
11. Tip the jar over a disposable cup and pour the contents into the disposable cup. This is the kidney filtering the blood.
12. Observe what the filter traps and what it doesn't and record your observations in the data table.

## **BONUS Third Experiment: Kidney Stones**

13. A kidney stone is something that develops in the urinary tract from a crystal. Crystals start from "seed crystals" that grow when placed in the right solution.
14. Use a pipe cleaner to create a shape for crystals to cling to (suggestion: cut into 3 lengths and wrap around one another). Curl the top pipe cleaner around a pencil, making sure the shape will hang nicely in the container without touching the sides.
15. Add 2 cups of water and 2 cups of borax (sodium tetraborate) into a pot. Heat, stirring continuously for about 5-10 minutes. Do not boil, but only heat until steam rises from the pan.
16. When the borax has dissolved, add more, and continue to do so until there are bits of borax settling on the bottom of the pan that cannot be stirred in (It may be necessary to stop heating and let the solution settle if it gets too cloudy). You'll be adding in a lot of borax! You have now made a supersaturated solution. Make sure your solution is saturated, or your crystals will not grow.
17. Wait until your solution has cooled to about 130°F (hot to the touch, but not so hot that you yank your hand away). Pour this solution (just the liquid, not the solid bits) into the jar, and add the pipe cleaner shape. Make sure the pipe cleaner is submerged in the solution. Put the jar in a place where the crystals can grow undisturbed overnight, or even for a few days. Warmer locations (such as upstairs or on top shelves) are best.
18. NOTE: These crystals are NOT edible! Please keep them away from small children and pets!





## Kidneys Filtration Data Table

Amount of Chalk or Sand	Amount of Water	Color of Water after Mixed	Amount of Solids Filtered Out by Cheesecloth

### Reading

Urine tests look at different components of urine. Most urine tests are done to get information about the body's health and clarify problems that it might be having. There are over 100 different kinds of urine tests that can be done. Depending on the test, scientists look for different things.

The most obvious, and the one you can do yourself at home, is to look at the color of urine, which is normally clear. Many different things affect urine color, and the darker it is, the less water there is in it. Vitamin B supplements can turn it bright yellow. If you like to eat blackberries, beets or rhubarb, then your urine might be red-brown.

The next thing to check is smell. Since urine doesn't smell much, it's a signal if it suddenly takes on an unusual odor. For example, if you have an E. coli infection, your urine will take on a bad odor.

Scientists also check the specific gravity, which is a measure of the amount of substances in the urine. The higher the specific gravity number measures, the more substance is in the urine. For example, when you drink a lot of water, your kidneys add that water into the urine, which makes for a lower the specific gravity number. This test shows how well the kidneys balance the amount of water in urine. The specific gravity for normal urine is between 1.005-1.030.

pH is a measure of how basic or acidic something is, and for a urine test, it's the pH of the urine itself. A pH of 7 is neutral, a 9 is strongly basic, and a 4 is strongly acidic. Using a strip of pH paper will tell you how basic or acidic your urine is. Normally, pH is between 4.6-8.0 for urine.

Protein is not supposed to be in the urine, unless you're sick with a fever, just had a hard workout session, or are pregnant. Scientists look for protein to be present in the urine to detect certain kinds of kidney diseases.

Glucose is sugar in the blood, and usually there's no glucose in urine, or if there is, it's only a tiny bit. When scientists detect glucose in the urine, it means that the body's blood sugar levels are very high, and they know they need to look into things further.

When scientists find nitrites, they know that bacteria are present, especially the kind that cause a urinary tract infection because bacteria make an enzyme that changes nitrates to nitrites in the urine.

Strong, healthy people will have a couple of small crystals in their urine. If scientists find a large number of crystals, then they start looking for kidney stones. If they don't find kidney stones, then they start looking at how the body metabolizes food to see if there's a problem.

Most adults make about 1-2 quarts of urine each day, and kids make about 0.6-1.6 quarts per day

### **Exercises**

1. Which fluid produced more urine for the first experiment?
2. Did the caffeine solutions cause the calcite stones to shrink or have no effect?
3. What does pouring the chalky water through a coffee filter show?
4. What are kidney stones and how are they formed?

# Life Science 2 Evaluation

## Student Worksheet

**Overview:** Today you're going to take two different tests: the quiz and the lab practical. You're going to take the written quiz first, and the lab practical at the end of this lab. The lab practical isn't a paper test – it's is where you get to show your teacher that you know how to do something.

### Lab Test & Homework

1. Your teacher will call you up so you can share how much you understand about human anatomy and how it works. Since science is so much more than just reading a book or circling the right answer, this is an important part of the test to find out what you really understand.
2. While you are waiting for your turn to show your teacher how much of this stuff you already know, you get to choose which homework assignment you want to complete. The assignment is due tomorrow, and half the credit is for creativity and the other half is for content, so really let your imagination fly as you work through it. Choose one:
  - a. Write a short story or skit about human anatomy from the perspective of the muscle, bone, heart, lungs, or one of the five senses (taste, touch, sight, sound, or smell). You'll read this aloud to your class.
  - b. Make a poster that teaches the main concepts of human anatomy. When you're finished, you'll use it to teach to a class in the younger grades and demonstrate each of the principles that you've learned.
  - c. Write and perform a poem or song about the most fascinating part of human anatomy. This will be performed for your class.

# Life Science 2 Quiz

Name \_\_\_\_\_

1. What are ways that the human body can detect temperature?
2. What are the two main types of muscles?
3. Give two examples of a muscle group.
4. What is the smooth, hard, protective layer on the outside of bones called?
5. What is the inside spongy, porous, honeycombed bone called?
6. Which body system is the heart a part of? What are some of the jobs?
7. Which body system are your lungs a part of? What are some other parts in this system?
8. What is pH and how is it useful? What pH is considered acidic?
9. What is the process called that moves food along the digestive tract and how does it work?
10. What do your kidneys do, and how do they do it?



# Answers to Exercises and Quizzes

## Lesson #1: Robotic Hand

1. What types of muscles are connected to our bones? (voluntary muscles)
2. Which type of connective tissue connects our muscles to our bones? (tendons)
3. What do extensor tendons in our wrist do? (allow us to straighten our fingers and thumb)
4. What do flexor tendons do? (curl the fingers and thumb, bend the wrist)

## Lesson #2: Chemical Fingerprinting

1. What are the three main types of patterns on fingerprints? Describe each. (Loops start and end on the same side of a finger, arches go from one side of a finger to the other, and whorls are basically circular.)
2. How do fingerprints have the potential to help solve crime? (Fingerprints are unique to each individual. Prints from a crime scene can be compared to a database of fingerprints for possible matches.)
3. Why does baking soda (or washing soda) show up red on the paper? (They are bases, which interact with a chemical in the goldenrod paper).
4. What kind of pH do bases have? (bases have a high pH)
5. What kind of reaction do we see when the red fingerprints show up on the paper? (chemical reaction)

## Lesson #3: Detective Boxes

1. Name, in order, the three main layers of skin. (epidermis, dermis, and subcutaneous)
2. Which layer of skin contains the mechanoreceptors? Name two more items in this layer. (The dermis, which also contains (any two answers acceptable) hair follicles, blood vessels, sebaceous glands, nerve endings, etc.)
3. Name the five types of nerve endings and their specialization. (Meissner's endings respond to vibrations and light pressure, such as fluttering or stroking motions. Ruffini's endings respond to pressure and are sensitive to stretching. Merkel's endings detect moderate, steady pressure and provide information to the brain about texture. Pacini's endings detect deep, rapid vibrations. Free nerve endings are used in detecting pain.)

## Lesson #4: Detecting Temperature Changes

1. Which chemical when mixed with water was an endothermic (absorbed heat and felt cold) reaction? (Adding ammonium nitrate to water causes both its ammonium and nitrate ions to dissolve, which results in heat absorption as ionic bonds are broken. This is an endothermic reaction.)
2. Which chemical resulted in an exothermic reaction (gave off heat)? Why does this happen? (Calcium chloride splits into calcium ions and chloride ions when it is mixed with water. As this occurs, energy is released in the form of heat.)
3. What are ways that the human body can detect temperature? (Thermoreceptors are the nerve endings in our skin that detect changes in temperature. They're located in the dermis, or second layer of skin, and we have both cold receptors and warm receptors.)

## Lesson #5: Rubber Eggs

1. Describe what the eggshell looked like before the reaction. (Answers may vary but should include details such as color, thickness of shell, what type of surface the shell has, etc.)
2. Describe the acetic acid (Answers may vary but should include details such as color, viscosity, smell.)
3. The product you witnessed in this chemical reaction was carbon dioxide, a colorless, odorless gas. How can you tell there really was a chemical reaction? (bubbles formed)
4. Why did the egg turn to "rubber?" (The vinegar dissolved the calcium of the egg.)

### **Lesson #6: Foggy Hands**

1. How is sweat released from the body through the skin? (via pores)
2. How does sweat help to cool the body? (It's released onto the skin and evaporates, which is cooling.)
3. What did you observe at the 30 minute mark in your experiment? (Answers will vary, but the bag should be foggy and the hand will be wet.)
4. What is evaporation and how is it different from condensation? (Evaporation turns a liquid into a gas [or vapor], condensation turns it from a gas back to a liquid.)

### **Lesson #7: Finger Thermometers**

1. Does the temperature of the middle glass feel *warmer*, *cooler*, or the *same* when you touch it with your hand that was holding the warm glass? (cooler)
2. What does your hand that was touching the cold glass feel when it touches the middle glass? (warmer)
3. What do you feel when both hands are on the middle glass? (one feels warm and one feels cool)
4. Why do you think your hands are not the best instruments for determining temperature? (our hands detect changes in temperature, not actual temperature)
5. (Ruffini's endings)

### **Lesson #8: Cooling and Heating**

1. What is equilibrium? (a state of constant balance)
2. How does equilibrium relate to body temperature? (Equilibrium is our body's goal – it uses skin to help regulate temperature and achieve equilibrium.)
3. How does our body help to cool us down? (Sweat is released through pores, which evaporates to help cool us.)

### **Lesson #9: Testing Muscle Strength**

1. What are the two main types of muscles? (voluntary and involuntary)
2. Give an example of a muscle group that's more specific than your answers above. (example: cardiac muscles, smooth muscles)
3. Why aren't the muscles in our fingers big and strong like those in our arms and legs? (Different muscle groups have different functions – finger muscles need to be small and fast for small, detail-oriented movements.)

### **Lesson #10: Inside Bones**

1. Name some of the parts that make up our skeletal system. (bones and connective tissues like cartilage, joints, tendons, ligaments)
2. What is the smooth, hard, protective layer on the outside of bones called? (cortical bone)
3. What is the inside spongy, porous, honeycombed bone called? (cancellous bone)
4. What is the network of tubes inside bones called? (Haversian system)

### **Lesson #11: Tendon Reflex**

1. What are the main parts of the nervous system? (the central nervous system consists of the brain and spine, peripheral nervous system is nerves and other connectors that link our numerous body parts and organs back to the brain and spine)
2. What are the two parts of the peripheral nervous system and what are their functions? (somatic system sends messages from brain to limbs so that we can move our bodies, and collects information received from our five senses; autonomic sends information to our organs, blood, and other parts of the body and also controls involuntary reflexes)



3. Which part of the nervous system controls involuntary reflexes? (autonomic system)

### **Lesson #12: Detecting Plaque**

1. Why does this experiment work at detecting plaque? (Disclosing tablets are designed to identify plaque by turning it red.)
2. How can dentists and moms use this to make sure you're doing a good job brushing? (As a pop quiz!)
3. What is plaque, and why is it bad for you? (The buildup of things like food and bacteria where your gums and teeth meet, and also between your teeth, is called plaque. Where plaque lives is also where the bacteria turns the sugar in your mouth into harmful acids that attack your teeth's enamel and can lead to gum disease.)

### **Lesson #13: PTC Testing**

1. What are the tiny hair-like organelles that send taste messages to your brain called? (microvilli)
2. What are the bumps on your tongue called? (papillae)
3. What kind of trait does this experiment test? (a genetic trait – dominant or recessive gene)

### **Lesson #14: Testing Spit Samples**

1. What is the first step in the digestive process? (chewing or mastication)
2. How does saliva help to digest food? (It contains enzymes that break down starch in foods.)
3. Name one or more of the main salivary glands and where they are located. (parotid gland is near the back of the throat, submandibular gland is in the lower jaw, sublingual gland is under the tongue)

### **Lesson #15: Mapping Your Tongue**

1. How many different types of taste receptors do we have? What are they? (Four: sweet, salt, bitter, and sour.)
2. Can you still taste food when you have a stuffy nose? (We can only taste the four distinct true flavors of sweet, sour, salty, and bitter. Our nose works with our tongue to allow us to identify more complex flavors.)
3. Which taste receptors recognize the hydroxyl group? (sweet)

### **Lesson #16: Tasty Taste Buds**

1. How does saliva help with tasting? (it makes a solution with the food we eat, which can be analyzed by our taste buds.)
2. What helps to decode the chemical structure of a food so that the brain can determine its taste type? (taste receptors or taste buds)
3. Why do foods sometimes become less strong as we age? (Our taste buds are replaced every couple of weeks and fewer of them get replaced as we grow older.)

### **Lesson #17: Stethoscope**

1. Approximately how big is your heart? (about the size of a fist)
2. Which body system is the heart a part of? (cardiovascular system)
3. What are some of this system's jobs? (delivering nutrients and oxygen, disposing of waste, regulating body temperature, fighting disease, maintaining homeostasis)
4. How many chambers does your heart have and what are they called? (four chambers – left and right ventricle, left and right atrium)
5. How did the heart rate change when you exercised? Why did this happen? (The heart rate increases because of activity – increased activity means an increased need for oxygen in the muscles, so the heart works harder to deliver this oxygen.)

### **Lesson #18: Heart Rate Monitoring**

1. Explain how to take a pulse. (Find the pulse in your wrist with index and middle fingers, count for 6 seconds, then multiply by 10 to get the rate per minute.)
2. What units do we use to measure pulse? (beats per minute or bpm)

### **Lesson #19: What's Your Lung Capacity?**

1. Which body system are your lungs a part of? (respiratory system)
2. What are some other parts in this system? (trachea, diaphragm, nose, mouth, etc.)
3. Explain this system's major function. (Gas exchange – it brings in oxygen for fuel and dispels carbon dioxide and other waste products.)

### **Lesson #21: Detecting Carbon Dioxide**

1. What is pH and how is it useful? (a measurable scale that lets us know how acidic or basic something is)
2. What does a yellow color indicate with bromothymol blue? (acidic solution)
3. Is CO<sub>2</sub> acidic or basic? (slightly acidic, so it changes the solution green)

### **Lesson #22: Scent Matching**

1. What is the scientific name for sense of smell? (olfactory sense)
2. What is the name of the tissue which helps the brain to distinguish between smells? (olfactory epithelium)

### **Lesson #23: Swallowing**

1. What is the tube called that connects the mouth and stomach? (esophagus)
2. What is the process called that moves food along the digestive tract and how does it work? (peristalsis occurs when smooth muscles along the digestive tract expand and contract to move food)
3. How long is food in the esophagus? (only a few seconds)

### **Lesson #24: Diffusion**

1. Which odors travel the farthest? (answers vary – check your data table)
2. Which ones travel the fastest? (answers vary – check your data table)
3. Why do we use the fan? (It accelerates the natural process of air and odor molecules and moves them much farther and faster than they would go otherwise.)
4. Does air temperature matter? (The higher the air temperature, the faster the air and odor molecules will move.)

### **Lesson #25: Consuming Oxygen**

1. What do we mean when we say that oxygen is consumable? (It gets used up in a chemical reaction.)
2. What is the difference between an open and a closed system? (A closed system has a limited amount of a resource, like oxygen, available. An open system has an unlimited amount of oxygen, like the atmosphere. Note that the “unlimited” amount isn't really infinite, it's just a *huge* amount when compared to what's available in a cup.)
3. Where is the higher pressure in this experiment? (on the outside of the glass)
4. Why does water rise inside the glass? (Higher pressure pushes, and when the amount of oxygen inside the glass decreases, it creates a lower pressure inside the glass. This difference in pressure causes the higher pressure on the outside to push on the water, forcing it under the glass and up the cup.)

### **Lesson #26: Eye Balloon**

1. How does your eye work like a camera? (both have lenses, both produce images with lots of components working together)
2. How can you tell if a lens is double convex? (When you run your fingers across it, you feel a bump in the middle where the lens is thicker)
3. What is the difference between convex and concave? (A concave surface curves inward, while a convex surface bulges out.)
4. Can you give an example of an everyday object that has both a convex and a concave side? (spoon)
5. How can you change the balloon to make it near-sighted? (lightly push down on the top)
6. How can you change the balloon to make it far-sighted? (gently push in front and back of the balloon to make it taller)

### **Lesson #27: Water Lens**

1. What are the two main types of lenses? (convex and concave)
2. How are the two main types of lenses shaped? (convex bulges outward and concave dips inward)
3. How do the two main types of lenses work? (convex makes things appear larger, concave makes them appear smaller)

### **Lesson #28: Disappearing Frog**

1. What did you notice about the vision of the student and the blind spot that you measured? (answers vary)
2. Why do you think it's important to know where your blind spot is? (so you can expect it and work around it if you need to)

### **Lesson #29: Visual Reflex**

1. What is the voluntary response in this experiment? (The eyes see the ruler moving and tell the brain, which then tells the fingers to close quickly.)
2. What is an involuntary response in your body? (When you tap just below the knee cap and test your tendon reflex, or when you pull your hand away from a hot stove.)

### **Lesson #30: Camera Eyes**

1. How does the pupil adapt to light conditions? (Its diameter increases in the dark to allow in more light and decreases in bright light.)
2. What are the two special photoreceptors called and where are they located? (Rods and cones are located in our eye's retina.)
3. Which photoreceptor is used to help us see in the dark? (rods)

### **Lesson #31: Human Levers**

1. Draw a diagram of a first-class lever. Where in your body is this type of lever? (Your neck joint in the middle is the fulcrum, with load and effort on either side. In this example, load and effort switch depending on whether you are moving your head up or down. You'll also find this when you extend your elbow and lift a weight.)
2. Draw a diagram of a third-class lever. Where will you find this? (If you're sitting down and lifting a load with your legs straight out in front of you. You'll also find this in action when you swing a baseball bat at a ball or shovel snow. There is also an example of this at your foot when you stand on the tip of your toes. The axis would be at your toes, the resistance would be your leg bones (tibia), and the rest of your body and the force would be your calf muscles.)
3. Draw a diagram of a second-class lever. Can you give an example of this type of lever? (This is the most common lever in your body by far. An example would be your arm. The axis would be your elbow, the resistance is you

forearm and hand, and the force would be your biceps (think arm curls). You'll also find this by doing a push up, moving a wheelbarrow, using a nutcracker, rowing the oars of a boat.)

### **Lesson #32: Sound Speed**

1. What is density? (how tightly packed the molecules in substance are)
2. Put these in their general order of density: liquid, gas, solid. (solids are normally densest, liquids are next, gases are least dense)
3. Which material passes sound waves along farther and faster? (solids)

### **Lesson #33: Sound Matching**

1. What are the tiny bones in the ear called? (ossicles: hammer, stirrup and anvil)
2. Name some other parts of the ear (pinna, ear canal, ossicles, cochlea)

### **Lesson #34: Sound Whackers**

1. How is sound made? (All sound is made when something vibrates.)
2. How do you change the pitch of the ruler? (When a short piece is hanging over the edge, a high pitch is made. And when the length is longer, the pitch is lower.)

### **Lesson #35: Big Ears**

1. Which part of the ear is this experiment testing? (The pinna, or the funneling process.)
2. What happens when you change your variable in this experiment? (By making the pinna larger, you also increased their ability to pick up sound vibrations.)
3. Did this experiment change your ability to detect which direction a sound came from? (Yes – it makes it easier to detect sound direction.)

### **Lesson #36: Nerve Tester**

1. Where is the highest concentration of nerve endings in the body? (The tongue.)
2. What are nerve ends used for? (To collect data to keep us safe and survive!)
3. Where do you think the least amount of nerve ends should be in the body? (Backs, rear ends, and arms... parts that are least likely to bump into something.)

### **Lesson #37: All About Kidneys**

1. Which fluid produced more urine for the first experiment? (Answers vary, but it's usually sports drinks. Sports drinks create a high output of urine because most of them contain salt.)
2. Did the caffeine solutions cause the calcite stones to shrink or have no effect? (Caffeine will cause the calcite stone to grow.)
3. What does pouring the chalky water through a coffee filter show? (This illustrates how the kidneys trap the toxins before returning the purified blood to the body's circulatory system.)
4. What are kidney stones and how are they formed? (Kidney stones form from salts and minerals in the body when the concentration of waste is high enough to form a solution that enables the crystal to grow. People who get too much calcium, especially as a supplement, are more likely to get kidney stones also.)

# Vocabulary for the Unit

absorption - Process in which substances are taken up by the blood; after food is broken down into small nutrient molecules, the molecules are absorbed by the blood.

acne- Pimples caused by blocked oil glands.

aerobic exercises- Types of exercises that cause the heart to beat faster and allow the muscles to obtain energy to contract by using oxygen.

alveoli – grape-like sacs where gas exchange occurs in the lungs

anabolic steroids- Hormones that cause the body to build up more protein in its cells.

anaerobic exercise- Types of exercises that involve short bursts of high-intensity activity; forces the muscles to obtain energy to contract without using oxygen.

antibody – Chemical that identifies and destroys harmful substances

artery – Blood vessel that carries blood away from the heart

asthma – chronic disease caused by an inflammation of the bronchioles

atherosclerosis – Buildup of plaque in the arteries

atrioventricular valve – Valve separating each of the heart's atria from the ventricles

atrium – One of the two chambers at the top of the heart that gets blood from other parts of the body

autonomic nervous system – Part of the motor division of the PNS controlling involuntary motions

axon – Part of the neuron that sends impulses to other cells

bacteria – Single-celled organisms without a nucleus

ball and socket joints- Joint structure in which the ball-shaped surface of one bone fits into the cuplike depression in another bone; examples include the shoulder and hip joints.

body odor- Smell that is produced by the breakdown of sweat by bacteria that live on the skin.

body system – group of organs and tissues working together towards a common purpose

bone marrow- Soft connective tissue found inside many bones; site of blood cell formation.

brain – Complex organ that is the control center of the body

brain Stem – Part of the brain that controls basic body functions such as breathing, heartbeat, and digestion

bronchi – tube leading from the trachea into the lungs

bronchiole – smaller tubes the bronchi branch into

bronchitis – disease caused by an inflammation of the bronchi

capillary – Small blood vessel connecting arteries and veins where oxygen transfer takes place

capillary Bed – Network of capillaries providing oxygen and nutrients to organs

carbohydrates - Nutrients that include sugars, starches, and fiber; give your body energy; organic compound.

cardiac muscle- An involuntary and specialized kind of muscle found only in the heart.

cartilage- Smooth covering found at the end of bones; made of tough collagen protein fibers; creates smooth surfaces for the easy movement of bones against each other.

cell body – Part of the neuron that contains the nucleus and organelles

central nervous system (CNS) – Part of the nervous system consisting of the brain and spinal cord

cerebellum – Part of the brain that controls body position, coordination, and balance

cerebrum – Part of the brain that controls voluntary motion and speech

chemical digestion - Digestion in which large food molecules are broken down into small nutrient molecules.

cilia – Small hairs that push mucus and pathogens out of your body

circulation – The movement of blood around the body

cochlea – Liquid-filled cavity in the ear

compact bone- The dense, hard outer layer of a bone.

connective tissue- Tissue that is made up of different types of cells that are involved in structure and support of the body; includes blood, bone, tendons, ligaments, and cartilage.

constipation - Having three or less bowel movements each week.

contraction - Shortening of muscle fibers.

cornea – Clear protective layer on the outside of the eye

coronary circulation – The process of providing oxygen to the heart muscle

coronary heart disease – Atherosclerosis blocking blood flow to the heart

dairy - Milk products.

dendrite – Part of the neuron that receives nerve impulses

dermis- The layer of skin directly under the epidermis; made of a tough connective tissue that contains the protein collagen.

dialysis – artificial kidney function

diaphragm – sheet of muscle that contracts or relaxes to let air into and out of the lungs.

diastolic pressure – Measure of the lowest blood pressure

diet - The sum of the food and drinks consumed by a person, especially in regard to his or her health.

digestion - Process of breaking down food into nutrients.

duodenum - The first part of the small intestine; where most chemical digestion takes place.

eardrum – Part of the ear that vibrates from sound waves

elimination - The process in which solid food waste passes out of the body.

enzymes - A substance—usually a protein—that speeds up chemical reactions in the body.

epidermis – Outer layer of skin

epidermis- The outermost layer of the skin; forms the waterproof, protective wrap over the body's surface; made up of many layers of epithelial cells.

epiglottis – flap of connective tissue that covers the trachea when eating to prevent choking

epithelial tissue- A tissue that is composed of layers of tightly packed cells that line the surfaces of the body; examples of epithelial tissue include the skin, the lining of the mouth and nose, and the lining of the digestive system.

esophagus - The narrow tube that carries food from the throat to the stomach.

excretion – act of removing waste from the body

excretory system – group of organs that removes waste from the body

exhalation – movement of air out of the body

extensor - The muscle that contracts to cause a joint to straighten.

external respiration – the process of air entering the body, going to the lungs and exchanging oxygen for carbon dioxide

fever – Raising of the body temperature above normal

fixed joints- Joints which do not move, skull joints, for example.

flexor- The muscle that contracts to cause a joint to bend.

food allergy - A condition in which the immune system reacts to harmless substances in food as though they were harmful.

fruit - A sweet, fleshy part of a plant which can both be eaten and has at least one seed.

fungi – Simple organisms that can have one or more cells

genetic – Able to be passed on from parents to offspring

gliding joints- Joint structure that allows one bone to slide over the other; examples includes the joints in the wrists and ankles.

grains - Any food made from wheat, rice, oats, cornmeal, barley or another cereal grain is a grain product. Bread, pasta, oatmeal, breakfast cereals, tortillas, and grits are examples of grain products.

earing – The ability to detect sound

heart Attack – The complete blockage of a coronary artery

hemoglobin – Oxygen-carrying protein

hereditary – able to be passed on from parents to children

hinge joints- Joint structure in which the ends of bones are shaped in a way that allows motion in two directions only (forward and backward); examples include the knees and elbows.

homeostasis- The ability of the body to maintain a stable internal environment in the response to external changes.

hormones - Regulatory molecules used in many bodily processes, including digestion.

hyperopia – Vision disorder in which light is focused behind the retina

hypertension – Disease in which a person always has high blood pressure

hypodermis- Fatty layer of tissue that lies under the dermis, but is not part of the skin, also called the subcutaneous tissue.

ileum - The third part of the small intestine; covered with villi; the few remaining nutrients are absorbed in the ileum.

immune response – Reaction of the body when a pathogen enters

infectious – Able to be spread from one person to another

inflammation – Reaction to infection involving increased blood flow

ingredients - A specific item that a food contains.

inhalation –movement of air into the body

insoluble fiber - Large, complex carbohydrate; does not dissolve in water; moves through the large intestine and helps keep food waste moist so it can pass easily out of the body.

integumentary system- The outer covering of the body; made up of the skin, hair, and nails.

internal respiration – the process of blood taking oxygen to the cells of the body and exchanging it for carbon dioxide

involuntary muscle- A muscle that a person cannot consciously control; cardiac muscle and smooth muscle are involuntary.

iris – Colored part of the eye around the pupil



jejunum - The second part of the small intestine; where most nutrients are absorbed into the blood; lined with tiny "fingers" called villi.

joints- Point at which two or more bones meet.

keratin- Tough, waterproof protein that is found in epidermal skin cells, nail, and hair.

kidney – organ that filters urine

kidney stone – crystalized nitrogen-bearing compound that can lead to intense pain

ligaments- Fibrous tissue that connects bones to other bones; made of tough collagen fibers.

lipids - Nutrients such as fats that are rich in energy; organic compound.

lymphocytes – White blood cells involved in the immune response

lysozymes – Enzymes that kill pathogens

mechanical digestion - Digestion with the teeth.

melanin- The brownish pigment that gives skin and hair their color.

minerals - Chemical elements that are needed for body processes.

motor division – Part of the PNS that sends messages from the brain back to the internal organs

motor neuron – Neuron that carries messages from the brain and spinal cord to the organs and muscles

movable joints- Most mobile type of joint; the most common type of joint in the body.

mucus – Moist sticky substance that traps pathogens

mucus membrane – Area of the body not covered by skin

muscle fibers - Long, thin cells that can contract; also called muscle cells.

muscle tissue- Tissue that is composed of cells that have filaments that move past each other and change the size of the cell. There are three types of muscle tissue: smooth muscle, skeletal muscle, and cardiac muscle.

myelin – Fatty layer that allows nerve impulses to move more quickly

myopia – Vision disorder in which light is focused in front of the retina

MyPlate - Diagram that shows what portions of which food groups you should include in your diet (updated from MyPyramid).

MyPyramid - Diagram that shows how much you should eat each day of foods from six different food groups.

negative feedback loop- A mechanism of control in the body in which the result of a bodily function acts as a signal to stop.

nerve – Group of nerve cells

nerve impulse – Message sent by the nervous system

nervous tissue- Composed of nerve cells and related cells.

neuron – Nerve cell that sends messages throughout the body

noninfectious – Not able to be spread from one person to another

nutrients - Chemicals in food that your body needs.

nutrition facts - The label on packaged food that shows the nutrients in the food.

oil glands- Skin organ that secretes an oily substance, called sebum, into the hair follicle.

organ – Group of specialized cells working together

organ system – A group of organs working together

organelle – Small structure inside a cell

parasympathetic division – Division of the autonomic nervous system that controls involuntary motion under normal circumstances

partly movable joints- Joints which can only move in one direction; for example, elbows.

pathogen – Substance capable of causing infection or disease

periosteum- Tough, shiny, white membrane that covers all surfaces of bones.

peripheral nervous system (PNS) – Part of the nervous system consisting of all the nerve cells outside the CNS

peristalsis - The wave-like movement of the intestinal muscles used to move food from the esophagus to the anus.

phagocyte – White blood cell that engulfs and destroys pathogens and debris

phagocytosis – Process in which phagocytes destroy pathogens and debris

pharynx – tube through which food and air travels; commonly called the throat

pinna – The outer ear

pivot joints- Joint structure in which the end on one bone rotates within a ring-type structure which can be made partly of bone and partly of ligament; example includes the joint between the radius and ulna.

plaque – Material that can build up

plasma – The liquid part of blood

platelet – Part of the blood that assists in clotting

protein - Nutrients made up of smaller molecules called amino acids; give your body energy; help control body processes; organic compound.

protozoa – Single-celled organisms with nuclei

pulmonary Artery – Artery that takes blood from the heart to the lungs

pulmonary circulation – Circulation of blood from the heart to the lungs, and back to the heart

pulmonary vein – Vein that takes blood from the lungs back to the heart

pupil – Small opening in the eye that lets in light

red blood cell – Disc-shaped cell that carries oxygen

reflex Arc – Nerve impulse that only makes it to the spinal cord, and never gets to the brain

retina – Area at the back of the eye on which light is focused

sebum- An oily substance secreted by oil glands which breaks down bacteria.

secretions – Things that come out of the body

semicircular canals – Liquid filled part of the ear involved in balance

semilunar valve – Valve separating each of the heart's ventricles from the arteries leaving the heart

sensory division – Part of the PNS that sends messages from sense organs to the brain

sensory neuron – Neuron that sends messages from the organs to the brain and spinal cord

skeletal muscle- The muscle that is usually attached to the skeleton.

skeletal system- Body system that is made up of bones, cartilage, and ligaments.

skeletons- Sturdy scaffolding of bones and cartilage that is found inside vertebrates.

skin- The largest organ in the body. It covers the body; keeping water out, and helping keep the temperature stable inside.

skull – Bones that protect the brain

small intestine - The narrow tube between the stomach and large intestine where most chemical digestion and absorption of nutrients take place.

smooth muscle- Involuntary muscle found within the walls of organs and structures such as the esophagus, stomach, intestines, and blood vessels.

soluble fiber - Large, complex carbohydrate; dissolves in water; helps keep sugar and fat at normal levels in the blood.

somatic nervous system – Part of the motor division of the PNS controlling voluntary motion

sphygmomanometer – Tool used to measure blood pressure

spinal cord – Tube of neurons that carries messages to and from the brain

spongy bone- Lighter and less dense than compact bone; found toward the center of the bone.

sprains- A ligament injury; usually caused by the sudden overstretching of a joint which causes tearing.

stretching exercises- Exercises which warm-up the muscles.

stroke – Disease caused by atherosclerosis of the arteries providing blood to the brain

sweat glands- Gland that opens to the skin surface through skin pores; found all over the body; secretes sweat.

sympathetic division – Division of the autonomic nervous system that controls the “fight or flight” response

synapse – Place where axons and dendrites meet

systolic blood pressure – Measure of the highest blood pressure

taste buds – Clusters of sensory neurons found on the tongue

tissue- A group of cells that work together for a common purpose.

touch – Sense of pain, pressure, and temperature

trachea – tube through which air travels on its way to the lungs

urea – nitrogen-containing compound in the urine

ureter – tube that moves urine from the kidneys to the urethra

urethra – tube through which urine leaves the body

urinary bladder – organ that stores urine before it is released

urinary system – group of organs that remove urine waste from the body

urine – combination of water and liquid wastes in the body

USDA - United States Department of Agriculture.

vector – Organism that transfers disease

vegetables - Any vegetable or 100% vegetable juice counts as a member of the vegetable group. Vegetables may be raw or cooked; fresh, frozen, canned, or dried/dehydrated; and may be whole, cut-up, or mashed.

vein – Blood vessel that brings blood back to the heart

ventricle – One of the two chambers at the bottom of the heart that pumps blood to other parts of the body

vertebrae – Bones that protect the spinal cord

virus – Non-living pathogen that takes over cells by injecting genetic material

vitamins - Substances that the body needs in small amounts to function properly.

voluntary muscle- A muscle that a person can consciously control; skeletal muscle is voluntary.

water - One of the essential nutrients needed by the body.

white blood cell – Blood cell that protects the body from disease

yellow marrow- The bone marrow that makes white blood cells.