LIFE SCIENCE 2

PARENT/TEACHER'S GUIDE

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.

Created by Aurora Lipper, Supercharged Science

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

Introduction to the Unit

Greetings and welcome to the unit on Life Science, Part 2: Human Anatomy. I hope you will find this helpful in preparing to teach your students, exhaustively thorough in content and a whole lot of fun, because that's when students and teachers do their best work.

This curriculum course has been prepared to be completed over several weeks, completing 1-2 lessons per week. You will find that there are 37 lessons outlined to take you from an introduction of human anatomy on through several advanced physiology activities complex enough to win a prize at the science fair. If you complete this course and send your kids off, you'll find their high school teachers entirely blown away by their mastery of the subject, and then will really be able to fly with them. Each lesson has a Teacher Page and a Student Worksheet.

The following features on each set of the Teacher Pages:

- Overview: this is the main goal of the lesson
- Suggested Time: make sure you have enough for completing this lesson
- Objectives : these are the core principles covered with this lesson
- Materials: Gather these before you start
- Lab Preparation: This outlines any preparation you need to do ahead of time
- Lesson: This outlines how to present the topic to the students, stirs up interest and gets the students motivated to learn the topic
- Lab Time & Worksheets: This includes activities, experiments, and projects that reinforce the concepts and really brings them to life. You'll also find worksheets that make up their Scientific Journal.
- Background Lesson Reading: This is optional additional reading material you can utilize ahead of time to help you feel confident when the students ask questions during the Lab Time. I don't recommend giving this reading to the kids beforehand. If you must share it with them, then do so *after* the students have gotten a chance to roll around with the activities. By doing this, it teaches kids to ask their own questions by getting curious about the concepts through the experiments, the way real scientists do in the real world.
- Exercises & Answer Key: How well did you teach? How well did they learn? Time to find out.
- Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Immediately following the Teacher Pages are "Student Worksheets" for each of the activities. Each set of student worksheets has the following sections:

- Overview
- What to Learn
- Materials
- Lab Time & Worksheets
- Exercises

In addition to the lessons, we have also prepared the following items you'll find useful:

- Scientific Method Guide
- Master Materials and Equipment List
- Lab Safety Sheet
- Written Quiz (with Answer Key)
- Lab Practical Test (with Answer Key)

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. The set of materials listed below is just for one lab group. If you have a class of ten lab groups, you'll need to get ten sets of the materials listed below. An easy way to keep track of your materials is to make up ten separate lab kits using small plastic tubs or baskets, fill each tub with the materials listed below, and copy these lists and stick them in the bin for easy tracking. Parts numbers are from www.hometrainingtools.com unless noted.

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

wax paper (1 sheet)

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Unit Prep

This is a short list of things that you may want to consider as you prepare for this unit.

Student Lab Books: If you're the kind of teacher who likes to prepare lab books for your kids, now is a good time to do this. You can copy the *Introduction for Kids* and the *Student Worksheets* for each of the experiments, 3-hole punch them, and stick it in a binder. You'll want one binder per student.

Science Journals: One of the best things you can do with your students is to teach them how to take notes in a journal as you go along. This is the same way scientists document their own findings, and it's a lot of fun to look back at the splattered pages later on and see how far you've come. I always jot down my questions that didn't get answered with the experiment across the top of the page so I can research these topics more.

Master Set of Materials: If you plan on doing all the labs in this unit, you'll want to start gathering your materials together. There's a master materials list so you'll have everything you need when you need it.

Test Copies: Students will take two tests at the end of each section. There are quizzes and lab practical tests you can copy and stash away for when you need them.

Classroom Design: As you progress through the units, you'll be making demos of the experiments and kids will be making posters. You can hang these up on your bulletin boards, string them from the ceiling, or display them in a unique way. I always like to snap photos of the kids doing their experiments and hang those up along with their best labs so they can see their progress as we go along.

Lab Safety

Goggles should be worn when working with chemicals, heat, fire, or projectiles. This protects 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.

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 these 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 experiments as appropriate.

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 do not contain the acid that alkaline batteries have. This means when your students wire up circuits incorrectly (which you should expect them to do because they 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 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.

Teaching Science Right

These activities and experiments will give you a taste of how science can be totally cool AND educational. But teaching science isn't always easy. There's a lot more to it than most traditional science books and programs accomplish. If your students don't remember the science they learned last year, you have a problem.

What do kids really need to know when it comes to science? Kids who have a solid science and technology background are better equipped to go to college, and will have many more choices once they get out into the real world.

Learning science isn't just a matter of memorizing facts and theories. On the contrary, it's developing a deep curiosity about the world around us, AND having a set of tools that let kids explore that curiosity to answer their questions. Teaching science in this kind of way isn't just a matter of putting together a textbook with a few science experiments and kits.

Science education is a three-step process (and I mean teaching science in a way that your students will really understand and remember). Here are the steps:

1. Get kids genuinely interested and excited about a topic.
2. Give them hands-on activities and experiments to make the topic meaningful.
3. Teach the supporting academics and theory.

Most science books and curriculum just focus on the third step and may throw in an experiment or two as an afterthought. This just isn't how students learn. When you provide your students with these three keys (in order), you can give them the kind of science education that not only excites them, but that they remember for many years to come.

So what do you do? First, don't worry. It's not something that takes years and years to do. It just takes commitment.

What if you don't have time? What I'm about to describe can take a bit of time as a teacher, but it doesn't have to. There is a way to shortcut the process and get the same results! But I'll tell you more about that in a minute. First, let me tell you how to do it the right way:

Putting It Into Action

Step one: Get students genuinely interested and excited about a topic. Start by deciding what topic you want your students to learn. Then, you're going to get them really interested in it. For example, suppose I want my fifth-grade students to learn about aerodynamics. I'll arrange for them to watch a video of what it's like to go up in a small plane, or even find someone who is a pilot and can come talk with the kids. This is the kind of experience that will really excite them.

Step two: Give your students hands-on activities and experiments to make the topic meaningful. This is where I take that excitement and let them explore it. I have flying lesson videos, airplane books, and real pilots interact with my students. I'll also show videos on how pilots plan for a flight. My students will learn about navigation, figuring out how much fuel is needed for the flight, how the weight the plane carries affects the aerodynamics of it, and so much more. (And did I just see a spot for a future math lesson also?) I'll use pilot training videos to help us figure this out (short of a live demo, a video is incredibly powerful for learning when used correctly).

My students are incredibly excited at this point about anything that has to do with airplanes and flying. They are all positive they want to be pilots someday and are already wanting flying lessons (remember - they are only fifth-graders!).

Step three: Teach the supporting academics and theory. Now it's time to introduce academics. Honestly, I have my pick of so many topics because flying includes so many different fields. I mean, my students use angles and math in flight planning, mechanics and energy in how the engine works, electricity in all the equipment on board the plane, and of course, aerodynamics in keeping the plane in the air (to name just a few).

I'm going to use this as the foundation to teach the academic side of all the topics that are appropriate. We start with aerodynamics. They learn about lift and drag, make paper and balsa-wood gliders and experiment by changing different parts. They calculate how big the wings need to be to carry more weight (jelly beans) and then try their models with bigger wings. Then we move on to the geometry used in navigation. Instead of drawing angles on a blank sheet of paper, our workspace is made of airplane maps (free from the airport). We're actually planning part of the next flight my students will "take" during their geography lesson. Suddenly angles are a lot more interesting. In fact, it turns out that we need a bit of trigonometry to figure out some things.

Of course, a 10-year old can't do trigonometry, right? Wrong! They have no idea that it's usually for high school and learns about cosines and tangents. Throughout this, I'm giving them chances to talk with the pilot in class, share what they've learned with each other, and even plan a real flight. How cool is that to a kid?

The key is to focus on building interest and excitement first, then the academics are easy to get students to learn. Try starting with the academics and...well, we've all had the experience of trying to get kids do something they don't really want to do.

The Shortcut: Okay, so this might sound like it's time-intensive. If you're thinking "I just don't have the time to do this!" Or maybe "I just don't understand science well enough myself to teach it to my students at that level." If this is you, you're not alone.

The good news is, you don't have to. The shortcut is to find someone who already specializes in the area you want your students to learn about and expose them to the excitement that the person gets from the field. Then, instead of you being the one to invent an entirely new curriculum of hands-on activities and the academics, use a solid science program or curriculum (live videos, not cartoons). This will provide them with both the hands-on experiments and the academic background they need.

If you use a program that is self-guided (that is, it guides you and your students through it step-by-step), you don't need to be hassled with the preparation. That's what this unit is intended to do for you and your students. This program uses these components and matches your educational goals set by state standards.

This unit implements the three key steps we just talked about and does this for you. My hope is that you now have some new tools in your teaching toolbox to give your students the best start you can. I know it's like a wild roller coaster ride some days, but I also know it's worth it. Have no doubt that that the caring and attention you give to your students' education today will pay off many fold in the future.

Educational Goals for Life Science 2

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:

- An inherited trait can be determined by one or more genes.
- 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.
- Organ systems function because of the contributions of individual organs, tissues, and cells. The failure of any part can affect the entire system.
- How bones and muscles work together to provide a structural framework for movement.
- How to relate the structures of the eye and ear to their functions.
- 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).
- How levers confer mechanical advantage and how the application of this principle applies to the musculoskeletal system.
- How kidneys remove cellular waste from blood and convert it into urine, which is stored in the bladder.
- How blood circulates through the heart chambers, lungs, and body, and how carbon dioxide (CO_2) and oxygen (O_2) 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.
- 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.

Lesson #1: Robotic Hand

Teacher Section

Overview: Your body moves when 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?

Suggested Time: 30-45 minutes

Materials (per lab group)

- 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

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson 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.

Lesson

1. Who knows what body structures connect our muscles to our bones? (The different connective tissues can be confusing, so be sure to define tendons as the connective tissue that connects voluntary muscles to bones).
2. Without tendons, we wouldn't be able to walk, jump, carry things, or play a musical instrument. Tendons are the connective tissue that allows our voluntary muscles to respond the brain's commands to move our bones. Other types of connective tissue include ligaments and cartilage, but today we're focusing on the muscle-to-bone connecting tendons.
3. Today we're going to make a robotic hand, which will also rely on tendons in order to move. Our wrist has both flexor tendons, which curl our fingers and thumb, also allowing the wrist to bend, and extensor tendons, which allow us to straighten and extend our digits.

Lab Time

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. Using the pen, trace a grown-up's hand on the cardboard.
4. 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.
5. 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.
6. 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.
7. Be sure there is a segment line that indicates the mound where your thumb bends into the palm.
8. 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.
9. 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.
10. 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.
11. 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.
12. 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.
13. Cut your string into five equal pieces. If using nylon rope, have an adult help singe the ends to prevent fraying.
14. 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.
15. 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.

16. The rubber bands may not line up perfectly, depending on the portion used in each knot.
17. 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.

Exercises

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)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #1: Robotic Hand

Student Worksheet

Name____

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

Lab Time

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.
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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.

Exercises Answer the questions below:

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

Teacher Section

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.

Suggested Time: 30-45 minutes

Materials (per lab group)

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

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson 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.

Lesson

1. Ask students to name something in nature that is truly unique – no two are the same (snowflakes, fingerprints, etc.)
2. Fingerprints are so unique that even identical twins don't have matching prints. Twins' fingerprints might have many similarities, but they are ultimately NOT identical.
3. If you've read a mystery novel or watched a detective movie, you may know that fingerprints are sometimes used in forensics, or the science behind criminal law. This is because of the unique nature of fingerprints. If prints can be recovered from a crime scene, they can be compared to a database of known prints to find a possible match.
4. Since fingerprints are so different, there are many classifications to describe their unique characteristics. The three main types of shapes in primary fingerprint classification are loops, arches, and whorls (a mnemonic device for remembering these is LAW).
5. 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.
6. More specific classifications include plain arch, tented arch, central pocket whorl, radial loop and ulnar loop (based on the direction of loop opening – toward the ulna or radius bone in the lower arm). And many, many more!
7. Today's 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 so that you can investigate your loops, arches, and whorls!

Lab Time

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. Pour some water into the cup and add some baking soda (or washing soda). Swirl with your finger to mix.
4. 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*.
5. 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!
6. Check for fingerprint features such as whorls or loops and label them appropriately on your prints.
7. 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.
8. When you are finished studying your own prints, ask a volunteer to let you make prints of their fingers.

Exercises

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)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #2: Chemical Fingerprinting

Student Worksheet

Name____

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

Lab Time

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	

Exercises Answer the questions below:

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

Teacher Section

Overview: 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.

Suggested Time 30-45 minutes

Materials (per lab group)

- shoeboxes with lids (4)
- soup can
- pencil
- scissors
- razor with adult help
- sandpaper (1 sheet)
- wax paper (1 sheet)
- fabric (1 piece)
- plastic (1 sheet or a plastic bag)
- glue gun
- gloves
- partners

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson 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 corpsucles) 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.

Lesson

1. Ask students if anyone can name the layers of our skin (they may name dermis, epidermis, etc.)
2. Note that our skin has many different layers, and there are three main ones: epidermis, dermis, and subcutaneous.
3. The first layer, or epidermis, is the skin we can see. It consists mostly of dead skin cells.
4. The second layer is the dermis. This is our real skin. The dermis contains things like hair follicles, blood vessels, sebaceous glands, and nerve endings. Touch receptors called mechanoreceptors are also located in the dermis.
5. Mechanoreceptors are nerve endings and include
    a. Meissner's endings (or Meissner's corpsucles) 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.
    b. Ruffini's endings (or Ruffini corpuscles) respond to pressure. They are also sensitive to the stretching of skin and tendons.
    c. Merkel's endings (or Merkel receptors) detect moderate, steady pressure and provide information to the brain about texture.
    d. Pacini's endings (or Pacinian corpuscles) are embedded deep in the skin and can only detect rapid vibrations.
    e. Free nerve endings are the most common receptors in our skin and are essentially used in detecting pain.
6. In today's experiment, we're going to try out our mechanoreceptors and test whether we are able to hinder their effectiveness with some conflicting stimuli. Are you ready?

Lab Time

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. 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.
4. 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.
5. 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.
6. 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.
7. 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.
8. 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?

Exercises

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.)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #3: Detective Boxes

Name____

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

Lab Time

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? *(yes or no)*
1		
2		
3		
4		
5		

Exercises Answer the questions below:

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

Teacher Section

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.

Suggested Time: 30-45 minutes

Materials (per lab group)

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

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson 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 iconic bonds are broken. This is an endothermic reaction.

Lesson

1. 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.
2. What are some other parts of our skin that can help us to regulate temperature once our thermoreceptors detect it? (ex. sweat glands, blood vessels, etc.)
3. 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.
4. Today, we're going to be detecting temperature changes from endothermic chemical reactions.

Lab Time

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. Put about ½ cup of warm water in one of the baggies.
4. 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.
5. Now dispose of these ingredients down the drain. Flush with lots of running water.
6. Open the ammonium nitrate and fill its cap with pellets. Put these in the second baggie.
7. Start to pinch the ammonium nitrate through the plastic bag and check for a temperature change. Does anything happen in the absence of water?
8. Now put a small amount of water (about room temperature) into the bag. Fill it about ¼ of the way full.
9. 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.
10. 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.

Exercises

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 iconic 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.)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #4: Detecting Temperature Changes

Student Worksheet

Name______________________________

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

Lab Time

1. Put about ½ 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 ¼ 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?**

Exercises Answer the questions below:

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

Teacher Section

Overview: Students will discover what happens to the shell of a hard-boiled egg when they soak it in a glass of vinegar.

Suggested Time: 30-45 minutes

Objectives: Students will understand that properties of substances can change when the substances are mixed and that a chemical reaction can be detected by the formation of a gas.

Materials (per lab group)

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

Lab Preparation

1. Hard boil enough eggs for each lab group
2. Assemble items above and have them ready for each lab group.
3. Print out copies of the student worksheets.
4. Read over the Background Lesson Reading before teaching this class.
5. Watch the video for this experiment to prepare for teaching this class.

Background Lesson 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 ($CaCO_3$). 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.

Lesson

1. Hold up a hard-boiled egg and ask students to predict what will happen if you drop it (you'll hear a "thud" and the shell will crack). If you have an extra egg, demonstrate this. Ask if anyone has a guess as to what the shell is made of. Allow several students to hazard a guess then tell them it has calcium, just like in bones. Say, "Actually, the calcium is part of a compound called calcium carbonate, which is also found in limestone, chalk, marble, and coral. Calcium carbonate is a base.
2. Hold up the bottle of white vinegar. Ask students if they have ever seen or smelled vinegar and what its uses are (answers may vary, but vinegar may be used for cooking, cleaning, gardening, health, and many other things). Allow them to take a quick whiff if they've never smelled it before. Say, "Vinegar is also called acetic acid."
3. Explain that acids and bases, such as acetic acid and calcium carbonate, combine to form a chemical reaction. There are many ways to determine if a chemical reaction is happening, but one way is the formation of a gas. Ask, "How can we tell if a gas forms in a liquid? What might you see?" (bubbles). Explain that in today's experiment, they will witness the effect of acetic acid on the calcium carbonate of an egg, and what an interesting effect it is!

Lab Time

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. Place a hard-boiled egg into a glass or jar. Fill with enough vinegar to cover the egg and leave alone for 24 hours.
4. 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.

Exercises

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.)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #5: Rubber Eggs

Student Worksheet

Name____

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

Lab Time

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

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

Exercises Answer the questions below:

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

Teacher Section

Overview: Skin has another function that it 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.

Suggested Time 30-45 minutes

Materials (per lab group)

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

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson 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!

Lesson

1. Ask, "Do you think we sweat all the time, or just when we're hot or active?"
2. Sweat glands are actually always producing moisture on our skin, releasing it through the pores. When the 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 happening, but we definitely do when it’s really hot or we’re running around a lot.

3. By enclosing your hand in plastic, this moisture can’t evaporate as it normally would. In this experiment, the bag collects and condenses it. This condensation means that the sweat is turning from a vapor right back to a liquid. We’re going to observe what happens to our hand in the bag and record what we experience.

Lab Time

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. Record a description of how moist your hand is prior to putting it in the baggie. This is at *0 minutes*.
4. 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.
5. 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.*
6. 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.

Exercises

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.)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #6: Foggy Hands

Student Worksheet

Name____

Overview: Skin has another function that it 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

Lab Time

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	

Exercises Answer the questions below:

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

Teacher Section

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?

Suggested Time 30-45 minutes

Materials (per lab group)

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

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson 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 explain 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!

Lesson

1. Ask students to feel their hands – are they warm or cool? What happens when you rub them together? This creates friction and heat, which you can feel in your fingers.
2. Heat can move around from one thing to another. Our bodies are designed to detect changes in temperature and adjust accordingly.
3. Thermoreceptors are special sensory receptors in our skin which can detect temperature changes so that our bodies can adapt to the changes. These special sensors are located in the second layer of our skin, called the dermis.
4. We have both cold and warm thermoreceptors, but no "HOT" receptors. If we're unfortunate enough to grab something hot, both cold and warm thermoreceptors are activated (usually along with pain receptors!)
5. Ask your students if our bodies can accurately detect temperature. We are going to test our hands in this experiment!

Lab Time

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. Place the three glasses in front of you on a table. They should be in a row: left, middle and right.
4. 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.
5. 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.
6. 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.
7. 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?

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? (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)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #6: Finger Thermometers

Student Worksheet

Name____

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

Lab Time

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			

Exercises Answer the questions below:

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

Teacher Section

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.

Suggested Time: 30-45 minutes

Materials (per lab group)

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

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson 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.

Lesson

1. Our bodies like to keep temperature regulated. The ideal state for our bodies is something called equilibrium, which is a state of balance. The skin helps our body to keep everything in this constant and predictable state.
2. How does our body work to keep us warm when it's cold? (Answers will vary, but note that blood flow is reduced to the skin in order to slow down heat loss. Also, we get chill bumps and our hair stands on end in

an attempt to trap the warmer air closer to our bodies for insulation…which doesn't work all that well for most of us, but it does help furry and feathered animals!)

3. How does our skin help our bodies cool down? (Sweat is released through our pores, which evaporates and helps to cool us).
4. In this lab, we'll simulate three conditions: equilibrium, excess cold and excess heat.

Lab Time

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. 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.
4. 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.
5. 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.
6. 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.
7. 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?

Exercises

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.)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #8: Cooling and Heating

Student Worksheet

Name____

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

Lab Time

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		

Exercises Answer the questions below:

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

Teacher Section

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.

Suggested Time 30-45 minutes

Materials (per lab group)

- bathroom scale
- pencil
- partner

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson 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. Not fun!

Lesson

1. Ask your class if they can tell you how different types of muscles differ. Can they name some different types?
2. Not all muscles are huge and strong. Muscles serve many functions in our body, and their design is specialized according to their ultimate function.

3. We have involuntary muscles that we cannot move. These include cardiac muscles in the heart and smooth muscles in the digestive tract.
4. Voluntary muscles are also called skeletal muscles. They are also specialized by use. For example, our thigh muscles need to be big so that we can use them to walk, jump, and run, but how do we use our fingers?
5. Fingers are used for detail-oriented tasks like writing, typing, and tying shoes. It makes sense that finger muscles need to be fast and smaller to perform the precise movements required when performing these tasks.
6. Today, we will test the strength of various skeletal muscle groups.

Lab Time

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. Put the scale between your knees. Now squeeze it as hard as you can and have your partner record the scale's reading.
4. 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.

Exercises

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.)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #9: Testing Muscle Strength

Student Worksheet

Name____

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

Lab Time

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

Muscles	**Scale Reading** *(measure in pounds, kg, etc.)*
knees	
thighs	
ankles	
palms	
elbows	

Exercises Answer the questions below:

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

Teacher Section

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.

Suggested Time: 30-45 minutes

Materials (per lab group)

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

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson 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.

Lesson

1. In today's lesson, we're going inside our bones to learn what makes them so strong. But first, ask the class to name the largest and smallest bones in the human body (The largest is the femur in the thigh, the smallest is called the stapes and it's in the inner ear.)

2. Ask students what it is that makes our bones so strong. It's partly because they're made up of hard minerals like calcium and phosphorus, but there's something else at work inside our bones.
3. The outside of bones is made up of a hard, smooth, protective material called cortical bone. But inside, there's cancellous bone, or spongy bone. It has a honeycombed, porous nature that makes it lighter (so our bones are not quite so heavy to move around) and it also makes bones stronger. In the middle is our marrow, which produces blood cells.
4. The honeycombed tubes inside bones are called the Haversian system. The Haversian system is made up of collagen in part, but lots of minerals help to keep them strong.
5. How in the world can bones with holes in them be strong? Let's take a look at the experiment.

Lab Time

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. 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.
4. 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 when it's exposed to the weight?
5. Now take 20 more straws and arrange in a circle so that they are all held vertically in your hand.
6. 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.
7. 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.
8. Place some straws inside the tube. Fill the middle of the tube with straws, making sure they are tightly packed.
9. 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?
10. 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.
11. 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?
12. 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.

Exercises

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)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #10: Inside Bones

Student Worksheet

Name____

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

Lab Time

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

Exercises Answer the questions below:

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

Teacher Section

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.

Suggested Time: 30-45 minutes

Materials (per lab group)

- knee
- partner

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson 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.

Lesson

1. There are two main parts to the nervous system: the central nervous system and the peripheral nervous system. The central nervous system is our brain and spine. The peripheral nervous system consists of nerves and other fibers that connect our limbs and organs back to the central nervous system.
2. The peripheral nervous system is divided further into the somatic and autonomic systems. The somatic system sends messages from the brain to our limbs and back again, allowing for movement. The somatic system also collects the information that is received from our five senses and delivers it to the brain for interpretation.
3. The autonomic system sends information to the organs, blood, and other parts of the body, then back to the brain. Together, the autonomic system and the brain keep things going that we don't have to think about, but are still pretty important, like breathing and digesting food.
4. The autonomic system also controls reflexes. We're testing the involuntary reflexes of our autonomic nervous system today.

Lab Time

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. 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.
4. 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.
5. 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.

Exercises

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)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #11: Tendon Reflex

Student Worksheet

Name____

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

Lab Time

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

Exercises Answer the questions below:

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

Teacher Section

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.

Suggested Time 30-45 minutes

Materials (per lab group)

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

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson Reading

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.

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.

Lesson

1. Ask students to tell you how they are supposed to take care of their teeth. (Brushing twice a day, after each meal and flossing once per day).
2. Why do we take such good care of our teeth? (You may get various answers, including avoiding cavities.)
3. 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. Can anyone tell you what enamel is? (It's the protective surface that covers teeth.)

4. Enamel is made up of minerals, like calcium, and it's very durable. But unfortunately plaque isn't completely impenetrable.
5. If they aren't removed by brushing and, yes, even 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.
6. 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.
7. In this experiment we'll really ***see*** how important it is to brush thoroughly – and yes, even floss!

Lab Time

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. 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!*
4. 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.
5. 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.

Exercises

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.)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #12: Detecting Plaque

Student Worksheet

Name____

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

Lab Time

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.

Detecting Plaque Data Table

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

Exercises Answer the questions below:

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

Teacher Section

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.

Suggested Time 30-45 minutes

Materials (per lab group)

- PTC paper, 1 vial
- family members

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson 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. Congratulations!

Lesson

1. Ask everyone to stick out their tongues. If you have a mirror, they can inspect their own tongue or you might have them look at a friend's tongue.
2. Ask if anyone knows what the tiny bumps are called. Although many people think they are taste buds, they are actually papillae.
3. Most papillae do contain taste buds, but it's the tiny microvilli which have taste receptors that send information about taste to the brain.
4. What are the four main types of taste? (Sweet, sour, salty, and bitter).
5. Today, we're going to test out our bitter taste buds, but more specifically we're going to test for 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).
6. 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.

Lab Time

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. 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.
4. After testing your paper, be sure to note whether you are a *taster* or *non-taster*.
5. 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.
6. 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. Circle the names of family members who test positive and leave the negative testers un-circled.

Exercises

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)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #13: PTC Testing

Student Worksheet

Name____

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

Lab Time

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?

Exercises Answer the questions below:

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

Teacher Section

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.

Suggested Time: 30-45 minutes

Materials (per lab group)

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

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background 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.

Lesson

1. Ask if anyone can tell you the first step in the digestive process.
2. The very first thing the body does to break down food is chew it (also called mastication). However, there's something else in your mouth that also helps in digestion. Ask if anyone knows what it is.
3. Saliva contains special enzymes which start to break down starchy foods as soon as it comes in contact with them.
4. There are three main sets of salivary glands in your mouth. They are the parotid gland near the back of your throat, the submandibular gland, which is in the lower jaw, and the sublingual gland, which is under the tongue. Together, these glands secrete up to 2 liters of saliva daily!
5. Today we're going to test your saliva's power to begin the digestive process by testing for the presence of starch in a masticated – or chewed - piece of cracker.

Lab Time

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 plates with the marker. One will be for the water sample and one will be for the spit sample
4. 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.
5. Add a small amount of water with the pipette. Mix everything up with the craft stick to make a mash of cracker.
6. 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.
7. Take the pipette and squeeze a few drops onto the cracker mash in various spots. Record what you see in your experiment data.
8. 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.
9. Spit the mash onto the plate labeled "spit" once you have chewed for 2 minutes.
10. 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.

Exercises

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)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #14: Testing Spit Samples

Student Worksheet

Name____

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

Lab Time

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

Exercises Answer the questions below:

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

Teacher Section

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.

Suggested Time: 30-45 minutes

Materials (per lab group)

- cotton swabs (4)
- cups (5)
- black tea (1 bag)
- red vinegar
- sugar
- salt
- microwave
- water
- spoons
- partner
- blindfold

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson 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^+, such as the citric acid in a lemon), salt receptors respond to metal ions (like Na^+ 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.

Lesson

1. Ask your students to name the four main types of taste receptors? (sweet, sour, salty bitter)
2. When you bite into something flavorful, the enzymes in your saliva immediately start to break it down.
3. The tiny bumps on your tongue, called papillae, contain taste buds which have taste receptors. The solution made by the food and saliva goes to the taste receptors on your taste buds and they send the information to your brain, which interprets the taste as sweet, sour, salty or bitter.
4. Sweet taste receptors recognize hydroxyl groups in sugars, sour receptors respond to acids (such as citric acid in lemons), salt receptors respond to metal ions, bitter receptors are triggered by alkaloids. Each type of taste buds has its own distinct location on the tongue.
5. In this experiment, we'll learn approximately where each type of taste bud is located on your tongue.

Lab Time

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.
6. 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.

Exercises

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)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #15: Mapping Your Tongue

Student Worksheet

Name____

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.

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.

Suggested Time 30-45 minutes

Materials cotton swabs (4)

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

Lab Time

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:

    e. For the sweet cup, add two teaspoons to the warm water in one of the cups. Stir until well dissolved.
    f. For the sour cup, add 2 ounces of red vinegar to another cup and stir well.
    g. For the salty cup, put two teaspoons of salt into the final cup. Stir until dissolved.
    h. 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.
6. 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				

Exercises Answer the questions below:

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

Teacher Section

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.

Suggested Time 30-45 minutes

Materials (per lab group)

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

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson 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!

Lesson

1. Saliva plays an important role in taste as well as digestion. When food enters the mouth, saliva immediately begins to break it down.
2. The solution made by saliva and the food you're eating then move into the taste pores.
3. There are receptors in the taste pores which are able to determine the chemical structure of the food and send it on to the brain, where the type of taste is interpreted.
4. Ask your students if they can name the animal that has the most taste buds. It's actually a catfish and it has 175,000 taste buds all over its body.
5. The animal with the fewest taste buds is the chicken. They only have 24. Humans have approximately several thousand that are replaced every couple of weeks. As we age, fewer of our taste buds are replaced, which means flavors can become less strong than they once were.

Lab Time

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. (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.
4. 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.
5. 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.

Exercises

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.)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #16: Tasty Taste Buds

Student Worksheet

Name____

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

Lab Time

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?

Exercises Answer the questions below:

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

Teacher Section

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.

Suggested Time: 30-45 minutes

Materials (per lab group)

- rubber hose (3, 12-inch lengths)
- "T" connector or "Y" connector (both work fine)
- funnel
- stopwatch or clock with a second hand

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson 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_2) and oxygen (O_2) 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.

Lesson

1. Hold up your fist and ask your students which organ is about this size. Allow for guesses, and open and close your fist like a pumping, beating heart as a visual clue. Explain that the heart, along with blood and blood vessels, make up the circulatory system.
2. The circulatory system delivers oxygen and nutrients all over your body. It also disposes of waste (like carbon dioxide), regulates body temperature, fights disease, and generally keeps the body in homeostasis – which is a state of stability.

3. The heart is the center of the system and it really is about the size of your fist, and it's pure muscle that pumps blood throughout the body with regular, strong, rhythmic contracting pulses.
4. In humans, there are four chambers of the heart, two atria and two ventricles. These are the left atrium, right atrium, left ventricle and right ventricle.
5. All the chambers must work harder when activity increases. This is because increased activity means an increased need for oxygen in the muscles, so the heart works harder to deliver this oxygen.
6. Tell students that today they'll be making a stethoscope, which can be used to hear the heart of our cardiovascular system *and* the lungs that move the air through our respiratory system.
7. Explain to your students how to calculate beats per minute (use the stopwatch to count the beats heard in 15 seconds and then multiply this number by four).
8. Remind then to NEVER yell in the funnel. Ever, but especially if it's attached to someone's ears!

Lab Time

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. 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.
3. 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!**
4. 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.
5. 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?
6. 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.
7. For your data records, record how many times your heart beats in a minute while you are quiet and sitting.
8. 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.
9. 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.

Exercises

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.)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #17: Stethoscope

Student Worksheet

Name____

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

Lab Time

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

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

Exercises Answer the questions below:

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

Teacher Section

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.

Suggested Time: 30-45 minutes

Materials (per lab group)

- stopwatch or clock with a second hand
- pencil

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson 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!

Lesson

1. Ask your students to remind you which body system the heart is part of. It's the cardiovascular system.
2. One of the main functions of the cardiovascular system is the transport of oxygen from the lungs to all the rest of the body.
3. Ask students what happens to the heart when we exercise. It beats faster! This is because the muscles need more oxygen when they're active.
4. Together, the heart and lungs work to provide this needed oxygen. It's excellent teamwork!
5. Hold up your fist and open and close it, mimicking a heart's pumping action. Ask your students to show you what might happen to the heart when you run. Remind students that their heart is approximately as big as their fist. This tiny organ pumps all the blood that your body needs.

6. Although it varies by age and fitness level, the average heart rate is 70 beats per minute (bpm). Today we're going to monitor our pulse at rest and then check how activity changes it.
7. To check our pulse, first we'll find it in our wrist using the middle and index fingers. Next, use the stopwatch or clock to time six seconds while counting beats. This will be the time we record. Beats per minute (bpm) can be calculated by multiplying this observation by 10.

Lab Time

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. 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.
4. 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.
5. 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.
6. 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.

Exercises

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

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #18: Heart Rate Monitoring

Student Worksheet

Name____

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

Lab Time

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

Activity	**6-second pulse**	**bpm** *(6-second pulse x 10)*
sitting		

Exercises Answer the questions below:

1. Explain how to take a pulse.

2. What units do we use to measure pulse?

Lesson #19: What's Your Lung Capacity?

Teacher Section

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.

Suggested Time: 30-45 minutes

Materials (per lab group)

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

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson 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!

Lesson

1. Ask your students to name an involuntary bodily function, one that your body does automatically and you don't have to think about it. Chances are, someone will mention breathing.
2. We breathe via our respiratory system. Ask students to name the primary organ in this system (lungs!)
3. Our lungs take in much-needed oxygen so that our cells can obtain oxygen, which is needed to interact with glucose and fuel the body.
4. What are some other pieces of the respiratory system? Other parts include the nose, mouth, trachea, and diaphragm.

5. The main function of the respiratory system is gas exchange – it brings in oxygen and takes away carbon dioxide. Our lungs take in oxygen gas, which is needed to interact with glucose and fuel the body. The air exiting our body is full of carbon dioxide and other gas wastes that our bodies don't need.
6. Today, you will make a calibrated, or marked, container that you will use to measure your lung capacity. You will fill the calibrated container with water, slide a hose into it, take a really deep breath, and blow in the hose. As the air in your lungs enters the container, it will push out the water inside. Just blow as long and as much as you can, then when you flip the bottle over you will be able to read the amount of water you have displaced.
7. If you subtract the water displaced from the total amount of water in the bottle, the result is your lung capacity.

Lab Time

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. 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.
4. 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.
5. 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.
6. Put one end of the rubber hose in the top of the bottle (which should be now under water).
7. 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.
8. 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.
9. Record your lung capacity in your data records 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.

Exercises

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.)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson # 19: What's Your Lung Capacity?

Student Worksheet

Name____

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)

Lab Time

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.

Exercises Answer the questions below:

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

Teacher Section

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.

Suggested Time 30-45 minutes

Materials (per lab group)

- 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

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson 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.

Lesson

1. Ask your students which body part can intake material for both the respiratory system and digestive system. It's the mouth!
2. The mouth takes in food for digestions and air for breathing. Have any of your students wondered how everything gets where it's supposed to go?
3. Food and air diverge at the trachea and esophagus. Can your students tell you which organ does each function? The trachea carries air to the lungs, and the esophagus transports food to the stomach.
4. Today we will make a working lung model with tubing for a trachea, balloon lungs, and a knotted balloon for the diaphragm.
5. A fun fact for your students: Did you know that an average person breathes about 24,000 times each day? If you live to be 70 years old, that means about 600,000,000 breaths. Make them count!

Lab Time

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. Cut off the bottom of the 2-liter bottle. Ask an adult for help.
4. Take the "Y" valve and secure the two balloons to the top branches with the rubber bands.
5. Secure the stopper and use the drill to make a hole in it that's a little smaller than the diameter of the tubing.
6. 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.
7. 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.
8. 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.
9. 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 in the experiment's data.
10. Sketch your model and label its trachea, lungs, and diaphragm in the space below:

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #20: Working Lung Model

Student Worksheet

Name____

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

Lab Time

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 in the experiment’s data.
8. Sketch your model and label its trachea, lungs, and diaphragm.

Lesson #21: Detecting Carbon Dioxide

Teacher Section

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 $C0_2$ as waste. You will study this exchange in today's lab.

Suggested Time: 30-45 minutes

Materials (per lab group)

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

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson 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.

Lesson

1. Ask your students to recall the primary function of the respiratory system. It's gas exchange!

2. Which gases are exchanged, and how? Oxygen comes into the bloodstream via the air in your lungs. Carbon dioxide gets expelled as a waste product. The lungs are the hub for this gas exchange.
3. Today we will demonstrate this exchange using a pH indicator known as bromothymol blue.
4. When you exhale into a baggie, the carbon dioxide will react with water in the bag. This reaction produces carbonic acid, which starts to acidify the water. More breaths in the bag equal more carbon dioxide, which equal a lower (more acidic) pH.
5. You will notice the bromothymol will turn green when the pH of the water is right about 6.8 and it will turn yellow when the pH drops further to 6.0 and lower.

Lab Time

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. 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.
4. 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.*
5. 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.
6. 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***. ***Do not allow children to handle bleach or ammonia.***
7. 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.

Exercises

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_2 acidic or basic? (slightly acidic, so it changes the solution green)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #21: Detecting Carbon Dioxide

Student Worksheet

Name____

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 $C0_2$ 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!

Lab Time

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_2 Data Table

Solution	Color Change	Acidic or Basic?

Exercises Answer the questions below:

1. What is pH and how it is useful?
2. What does a yellow color indicate with bromothymol blue?
3. Is CO_2 acidic or basic?

Lesson #22: Scent Matching

Teacher Section

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.

Suggested Time: 30-45 minutes

Materials (per lab group)

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

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson 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.

Lesson

1. Ask students if anyone knows the scientific word for our sense of smell. It's olfaction, which is made possible by our olfactory system. More specifically, we smell with our olfactory epithelium.

2. Our noses are able to detect smells because odor molecules floating in the air. Everything from a rose to a boiled cabbage to an apple pie gives off tiny chemicals, which diffuse into the air. When these particles find our noses, they get caught in tiny hair-like structures and dissolve into the mucus inside the special membrane called the olfactory epithelium.
3. Did you know that your nose can get tired, and even take a nap? It's true. This is what happens when you help with holiday baking: After a while, you stop smelling all the yummy cookies. This is called olfactory fatigue and it's temporary. It occurs when your nose is bombarded by concentrated scent molecules. To wake up our nose, we can get some fresh air and our sense of smell will gradually return.
4. In this experiment, we'll test your olfactory sense to see how well your olfactory epithelium and brain work together to help distinguish between smells.

Lab Time

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. Your partner should be out of the room while you prepare this experiment.
4. 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.
5. 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.
6. 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.
7. 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?
8. Repeat step 7 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.

Exercises

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)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #22: Scent Matching

Student Worksheet

Name____

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

Lab Time

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?

Exercises Answer the questions below:

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

Teacher Section

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.

Suggested Time: 30-45 minutes

Materials (per lab group)

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

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson 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!

Lesson

1. Ask students when and how the digestive process starts. It's when we first put food in our mouth and start to chew. Chewing is mastication which breaks down the food and saliva contains enzymes that begin to digest the starches in food on contact.
2. Swallowing begins with the epiglottis, which is sort of a trap door that lets food into the esophagus. Can anyone tell you what the esophagus does? It connects the mouth and stomach….and it deposits chunks of food (called boluses) into the stomach for digestion.
3. The chewed bolus only stays in the esophagus a matter of seconds – which is really short considering it can take 2 or 3 days to finish the digestion process.
4. The movement that works the bolus, or chewed food, through the esophagus to the stomach is called peristalsis.

5. Peristalsis is the movement of muscles all along your digestive tract – these special smooth muscles expand and contract to move food along through various stages of digestion.

Lab Time

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. 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.
4. Put the tennis ball in one end of the nylon "esophagus."
5. Start using both hands to move the ball down the nylon tube until it arrives at the other end.

Exercises

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)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #23: Swallowing

Student Worksheet

Name____

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

Lab Time

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? *(measure in seconds)*

Exercises Answer the questions below:

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

Teacher Section

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 our 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.

Suggested Time: 30-45 minutes

Materials (per lab group)

- 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

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson 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 temperate 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!

Lesson

1. Ask your students to remind you what the sense of smell is called in biology (olfactory).

2. Can anyone remember the name of the tiny tissue inside the nose that distinguishes smells so that our brain can interpret them? It's the olfactory epithelium.
3. Smells begin as tiny molecules that are given off by items (and yes, even people). Can you think of a way where smells might be diffused, or spread around, more quickly? This happens when the air is moving around more.
4. We'll test scent diffusion in today's experiment.

Lab Time

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. 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.
4. You will need a simple 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.
5. 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. 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.
6. 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.
7. Repeat steps 5 and 6 with each item: cut and smash the lemon and press the garlic.

Exercises

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.)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #24: Diffusion

Student Worksheet

Name____

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

Lab Time

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.

Exercises Answer the questions below:

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

Teacher Section

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! Ready to give it a try?

Suggested Time: 30-45 minutes

Materials (per lab group)

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

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson 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.

Lesson

1. Ask the class to name some things your body must use every day. (Water, air, etc.) Ask what is in air that the body uses up. It's the oxygen, of course!
2. Your lungs contain over a thousand miles of air passages which work to absorb oxygen. If all of these could be spread out flat, an average set of lungs would have the surface area of about 650 square feet. That's the size of a small apartment or a really large room!
3. Air travels into your lungs via bronchioles, which are small airways in the lobes of your lungs. Bronchioles lead to alveoli, which are tiny grape-like sacs surrounded by capillaries.
4. The alveoli perform oxygen exchange in the blood along with the pulmonary capillaries. It's actually a very tiny two-cell barrier over which oxygen passes into the blood and carbon dioxide passes back out where it's expelled by your lungs into the air.
5. Your empty lungs create a low pressure environment, like a vacuum, and so your body sucks air back into your body again from the higher-pressure air all around you.
6. Today we'll see an example of what happens when oxygen is consumed and air pressure changes.

Lab Time

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. Pour about ¼ inch of water in the pan and place the dime right in the middle.
4. Position the candle next to the dime and ask an adult to light it for you
5. Put the drinking glass over the candle with its edge resting on the dime. Watch closely to observe what happens.
6. 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.

Exercises

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.

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #25: Consuming Oxygen

Student Worksheet

Name____

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!

Lab Time

1. Pour about ¼ 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

Trial Number	How Long Did the Candle Burn? *(measure in seconds)*	How High Did the Water Rise? *(measure in inches or cm)*

Exercises Answer the questions below:

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

Teacher Section

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.

Suggested Time: 30-45 minutes

Materials (per lab group)

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

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson 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.

Lesson

1. Did you know your eyes are similar to a camera? It's true. Both have lenses, and both use a series of interconnected parts which work together in order to produce an image.
2. In this experiment, we're going to make a balloon eye using a convex lens that mimics the lens in your eye.
3. We'll also mimic the conditions of near-sightedness and far-sightedness by gently changing the shape of the balloon.

Lab Time

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. 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.
4. 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 perpendicularl 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.
5. 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."
6. Help the kids put the candle on the table and light it. Turn out the lights.
7. 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.
8. 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.
9. The focal length is the distance from the flame to the image on the balloon. Measure this distance and record it.
10. 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.
11. 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?

Exercises

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)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #26: Eye Balloon

Student Worksheet

Name____

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!**

Lab Time

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 perpendicularl 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?	

Exercises Answer the questions below:

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

Teacher Section

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.

Suggested Time: 30-45 minutes

Materials (per lab group)

- 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
- water

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson 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.

Lesson

1. Lenses both transmit light and refract it. Refraction occurs when the light waves are turned or bent. Both our eyes and cameras contain lenses which refract the light we see.
2. Can your students name two basic types of lenses? They are convex and concave.

3. How do these convex and concave lenses look? Convex lenses bulge in the middle and concave lenses dip inward (the clue inside concave is "cave" – concave lenses go inward like an opening to a cave).
4. Today we'll make both kinds of lenses to see how they work. This helps to magnify what we're looking at, and is good for farsighted people who can't see far away things.

Lab Time

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. 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.
4. 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.
5. Put the washer and slide on the newsprint. Fill the pipette with water. 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.

Exercises

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)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #27: Water Lens

Student Worksheet

Name____

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

Lab Time

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

Water Lens Type *(concave or convex)*	**Draw a Diagram of the Lens**	**Draw a Diagram of the Newsprint**

Exercises Answer the questions below:

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

Teacher Section

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.

Suggested Time: 30-45 minutes

Materials (per lab group)

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

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson 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.

Lesson

1. This is a fun experiment to play with using different ages of people. As folks get older, the shape of the eye changes and the blind spot can actually change. Ask a few fellow adults to help you demonstrate the lab and measure the distance for the blind spot based on how old the adults are.
2. You can also test to see if different people with different vision have different blind spots. For example, is the blind spot the same for someone with 20/20 versus 20/40? Or with or without eyeglasses? Have fun with the different variations!

Lab Time

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. 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.
4. 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.
5. 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?
6. 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.

Exercises

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)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #28: Disappearing Frog

Student Worksheet

Name____

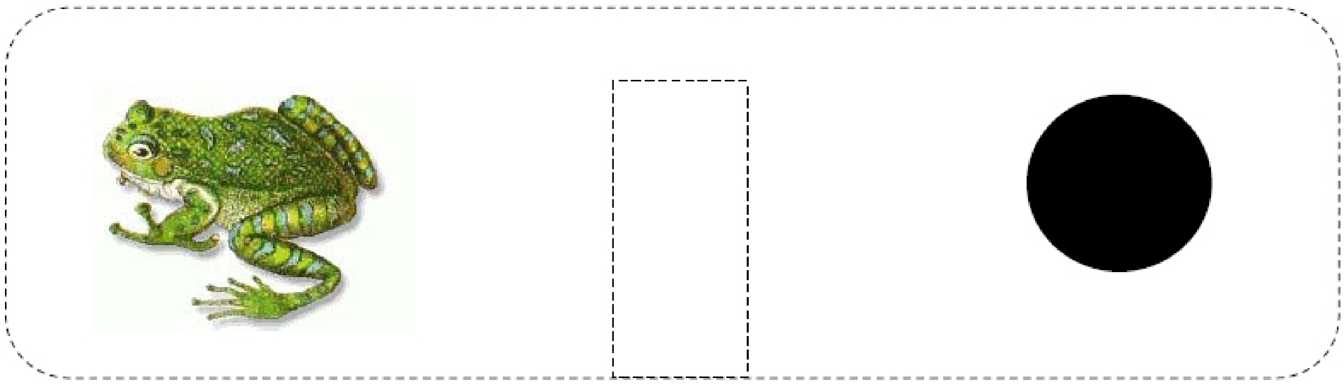
Overview Your optic nerve can be thought of as a data cord that is plugged in to each eye and connects them to your brain. The area where the nerve connects to the back of your eye creates a blind spot. There are no receptors in this area at all and if something is in that area, you won't be able to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

Materials

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

Lab Time

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

Exercises Answer the questions below:

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

Teacher Section

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.

Suggested Time 30-45 minutes

Materials (per lab group)

- ruler
- assistant
- pen

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson 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.

Lesson

1. This experiment studies a voluntary response. Can any of your students explain what this is?
2. A voluntary response is one we control, as opposed to an involuntary response like the knee reflex.
3. Involuntary responses, such as the one that happens when we pull our hand away from something hot, are much faster! This is because our decision-making process is out of the picture. The time it takes for a signal to move to our brain and back can waste valuable time when an involuntary response is needed in order to protect our bodies.

4. Today we'll test the speed of voluntary responses. In order for a voluntary response to take place in the case, the central nervous system sends a signal from the eyes to our brain, then down through the spinal cord and to the fingers.

Lab Time

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. You will begin by testing your visual reflexes with the help of an assistant.
4. 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.
5. 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.
6. 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.
7. Try this experiment with additional people. Find the average reaction speed of each person and the average speed of the group as a whole.

Exercises

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.)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #29: Visual Reflex

Student Worksheet

Name____

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

Lab Time

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

Trial number	Ruler Mark
1	
2	
3	
4	
5	
AVERAGE: *(total marks/total trials)*	

Exercises Answer the questions below:

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

Teacher Section

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.

Suggested Time: 30-45 minutes

Materials (per lab group)

- dark room
- light switch
- partner
- pencils

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson 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.

Lesson

1. Ask your students for ideas about how we are able to see in the dark.
2. One function that helps night vision is our pupil. It dilates, or increases in diameter, which allows more light to enter the eye in low-light situation like a dark room.
3. The retina in our eyes also has two different kinds of light receptors, called photoreceptors.
4. Cones, which help us to see color, are not as sensitive to light. However, rods, which see black, white and shades of gray are more sensitive to light changes. Which ones do you think we use more in the dark? The rods are used to see in dimness. This is why colors appear washed out in a darkened room.

5. What happens to pupils when the light comes on in a dark room? They shrink, or their diameter decreases, as they don't need to allow as much light into the eye to see.
6. Today we'll take a look at this pupil diameter adaptation.

Lab Time

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. Turn out the light in a darkened room and give your eyes about 5 minutes to get used to the darkness.
4. 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.
5. Now turn on the light while still observing your partner's eye. What happens to their pupil?
6. Draw another picture of your partner's eye with the lights on. Again, pay special attention to the diameter pupil of the eye.

Exercises

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)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #30: Camera Eyes

Student Worksheet

Name____

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

Lab Time

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

Exercises Answer the questions below:

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

Teacher Section

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.

Suggested Time: 30-45 minutes

Materials (per lab group)

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

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson 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

1. In a first-class lever, the fulcrum is in the middle with the load and effort on opposite ends. Can you think of an example? (see saw)
2. The fulcrum and effort are on opposite ends in a second-class lever. The load is in the middle. Can you think of an example of this? (wheelbarrow)
3. In a third-class lever, the fulcrum and load are on opposite ends with the force applied in the middle. A golf club is an example of a third-class lever.

4. In this lesson, we'll learn about examples of these levers in our bodies.

Lab Time

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. 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.
4. 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.
5. 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.
6. 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.

Exercises

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.)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #31: Human Levers

Student Worksheet

Name____

Overview: Levers are classified into three types: firs- 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

Lab Time

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.

Exercises Answer the questions below:

1. Draw a diagram of a first-class lever. Where in your body is this type of lever?

2. Draw a diagram of a third-class lever. Where will you find this?

3. Draw a diagram of a second-class lever. Can you give an example of this type of lever in the real world?

Lesson #32: Sound Speed

Teacher Section

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.

Suggested Time: 30-45 minutes

Materials (per lab group)

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

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson 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!

Lesson

1. How does sound travel? It travels in waves through the air, just like light.
2. Sound passes its energy through the material it's traveling.
3. Ask students which is densest: a solid, liquid, or gas? Which material do they think sound would travel better through?

4. You might think that sound travels best through the air, but that's not completely accurate so it can be a tricky question. Sound can travel through a solid, liquid, or gas, but how far and how fast depends on how tightly packed the molecules are, which indicates the material's density.
5. Ask students which is denser – water or air. Water is denser because its molecules are more tightly packed. Solids have very dense molecules. Because of their density, sounds pass through solids much faster and farther than sounds through less dense materials.
6. We'll test this in today's experiment.

Lab Time

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. 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.
4. Put the baggies on the desk or on a table. Note the density of the materials. Which is *most dense*, *medium*, and *least dense*?
5. 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.
6. 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*, to *medium*, to *quietest*.
7. 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.
8. 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*, to *medium*, to *quietest*.

Exercises

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)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #32: Sound Speed

Student Worksheet

Name____

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

Lab Time

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

Trial	Solid *(1 = quiet, 2 = loud)*	Liquid *(1 = quiet, 2 = loud)*	Gas *(1 = quiet, 2 = loud)*
spoon			
talking			

Exercises Answer the questions below:

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

Teacher Section

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.

Suggested Time: 30-45 minutes

Materials (per lab group)

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

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson 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.

Lesson

1. Ask students how sound travels. It travels through waves, which vibrate as they pass through materials. The vibration of these sound waves travel through the air and are picked up by the pinna, which is the external part of our ear.
2. Then, the sound waves travel down the ear canal and to the ear drum.
3. The ear drum contains three tiny bones – the smallest in your body. These bones are called the ossicles, also known as the hammer, stirrup and anvil.
4. The ossicles serve as the bridge between outer and inner ear. They amplify sound vibrations for the cochlea, the ear's fluid-filled inner chamber, which has a system of tubes that transforms sound waves into electrical impulses.
5. These impulses travel along the auditory nerve for interpretation by the brain.

Lab Time

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. Take the caps off the canisters. Number half of them *1* to *5* and mark the others with *A* through *E*.
4. 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.
5. Next fill the lettered containers. Be sure to record which container contains which material for reference.
6. 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.
7. Repeat step 6 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.

Exercises

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)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #33: Sound Matching

Student Worksheet

Name____

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

Lab Time

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?

Exercises Answer the questions below:

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

Lesson #34: Sound Whackers

Teacher Section

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.

Suggested Time: 30-45 minutes

Materials (per lab group)

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

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson 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.

Lesson

1. Ask students which organ collects and deciphers sound. (It's our ears, of course!)
2. Ask students how sounds travel. They travel via sound waves, or vibrations. Can your students give examples of things that vibrate to make sound? Vocal chords do this, as do guitars and other instrument strings. A ruler hanging over the edge of a desk and gently thumped or whacked will make a sound, too!
3. Length affects the pitch of a sound, so I hypothesize that the sound will change depending on the length of ruler hanging over the edge of the desk.
4. Let's test my theory in today's experiment.

Lab Time

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. 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.
4. 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?
5. 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.
6. 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?

Exercises

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.)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #34: Sound Whackers

Student Worksheet

Name____

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

Lab Time

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

Ruler length	Pitch *(1 is highest, 10 is lowest)*

Exercises Answer the questions below:

1. How is sound made?

2. How do you change the pitch of the ruler?

Lesson #35: Big Ears

Teacher Section

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.

Suggested Time 30-45 minutes

Materials (per lab group)

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

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson 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.

Lesson

1. We've learned that hearing is based on detecting sound waves vibrating through the air. Does your class remember what the outside of the ear is called? It's the pinna.
2. Sounds that we are able to detect can vary depending on the shape and size of our pinna. How does your class think larger pinna will impact your hearing?
3. Larger pinna should increase your hearing abilities! We'll test this in today's lab.

Lab Time

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. 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.
4. 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.
5. 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.
6. Repeat steps 4 and 5 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.
7. 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.
8. 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.

Exercises

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.)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #35: Big Ears

Student Worksheet

Name____

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

Lab Time

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? *(Scale of 0 – 10)*

Exercises Answer the questions below:

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

Teacher Section

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.

Suggested Time: 30-45 minutes

Materials (per lab group)

- paper clip, large
- ruler
- partner

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson 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!

Lesson

1. Ask students which sensory organ is our largest. It's the skin! Skin is one of our main conduits for connecting to the outside world. It's sensitive to various types of stimuli, such as temperature, touch, and pressure.
2. Our skin has receptors all over it, but some areas have a greater density of these receptors than others. Touch receptors called mechanoreceptors are located in the dermis, or second layer of our skin.
3. Mechanoreceptors are nerve endings (sometimes called corpuscles) and include the following

- Meissner's endings (or Meissner's corpsucles) 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.

4. Today we're going to test the density of receptors on the hand and arm.

Lab Time

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. 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.
4. 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.
5. 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.
6. 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.
7. Repeat steps 5 and 6, with the paperclip ends separated at a distance of 3 cm, 5 cm, and 10 cm.
8. Your turn! Switch places and have your partner test you and record your responses.
9. 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?

Exercises

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.)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #36: Nerve Tester

Student Worksheet

Name____

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

Lab Time

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?

Exercises Answer the questions below:

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

Teacher Section

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.

Suggested Time: 3-4 hours

Materials (per lab group)

- 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

For the optional Third Bonus Experiment:

- pipe cleaners
- cleaned out jar or bottle (pickle, jam, or mayo jar)

You'll need to prepare the solution ahead of time using these materials for the entire class:

- old pot
- stove or other heating appliance
- spoon
- borax

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.
4. If you are planning to do the optional third bonus experiment, then prepare the solution in advance so the students can use it during the lab. You'll prepare a small batch as the first part of their lab as a demonstration piece as well.

Background Lesson 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

Lesson

1. Explain to the students that in a nutshell, the kidneys remove waste from the blood and send it to the bladder.
2. You can make a model of the kidneys out of clay in advance for the kids to observe as you talk about the function of the kidneys. The kidney should be about the size of your fist and shaped like a kidney bean.

3. Label the upper part of the kidney as the adrenal gland, and explain how this part brings in blood to be filtered by the kidneys.
4. Label the tubes (called ureters), and explain how they run to the bladder and carry the waste produced from filtering the blood.
5. I like to build a model of both a healthy kidney and one that doesn't function properly (due to disease or age), for comparison.
6. Let the students know they are about to do two experiments with kidneys, the first of which is an experiment with their own kidneys, where they will figure out how fast their kidneys process different fluids.
7. The second part will determine how kidney filtration works.
8. Bonus Demonstration Idea: Ask if they think if caffeine (the stuff adults like in coffee) affects whether or not kidney stones will occur. The calcite stones are representing kidney stones in this experiment. Break several calcite stones so they are about the same size. Place then in separate disposable cups. Add enough soda to cover the stone in the first cup. Add enough coffee to cover the stone in the second cup. Add enough caffeinated tea to cover the stone in the third cup. Place in a warm location (like a sunny window or on a high shelf) and record your observations over the course of the month.

Lab Time

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.

First Experiment: How Quickly Do the Kidneys Process Fluids?

3. Drink a liter of water quickly (in less than five minutes).
4. 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.
5. Repeat four times so that you have four samples collected 20 minutes apart.
6. Repeat steps 3 – 5 for two different liquids, such as a sports drink and a soda.
7. Complete the data table for all three liquids.

Second Experiment: Kidney Filtration

8. 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.)
9. Fill the jar partway with water.
10. Add a few drops of red food coloring to the water.
11. The chalk (or sand) represents toxins in the blood. The water represents the blood.
12. Place a coffee filter (or cheesecloth) on top of the jar and secure with a rubber band. This coffee filter is your kidney.
13. Tip the jar over a disposable cup and pour the contents into the disposable cup. This is the kidney filtering the blood.
14. Observe what the filter traps and what it doesn't and record your observations in the data table.

BONUS Third Experiment: Kidney Stones

15. 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.
16. 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.
17. 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.
18. 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.
19. Wait until your solution has cooled to about 130^{o}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.
20. NOTE: These crystals are NOT edible! Please keep them away from small children and pets!

Exercises

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.)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #37: All About Kidneys

Student Worksheet

Name____

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

Lab Time

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^{o}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 Process Fluids Data Table

Record the pH and volume (did you urinate a lot, medium, or little?)

Drink Type	20 min	40 min	60 min	80 min

Kidneys Filtration Data Table

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

Exercises Answer the questions below:

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

Teacher Section

Overview: Kids will demonstrate how well they understand important key concepts from this section.

Suggested Time: 45-60 minutes

Objectives: Students will be tested on the key concepts of Human Anatomy:

- How levers confer mechanical advantage and how the application of this principle applies to the musculoskeletal system.
- 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.
- How levers confer mechanical advantage and how the application of this principle applies to the musculoskeletal system.
- How kidneys remove cellular wastes from blood and convert it into urine, which is stored in the bladder.
- How blood circulates through the heart chambers, lungs, and body, and how carbon dioxide (CO_2) and oxygen (O_2) are exchanged in the lungs and tissues.
- How contractions of the heart generate blood pressure, and heart valves prevent backflow of blood in the circulatory system.

Students will also demonstrate these principles:

- Know how to demonstrate how the eye works, and demonstrate common eye problems.
- Demonstrate how the body can be modeled by simple machines and joint models.

Materials (one set for entire class)

- Biconvex lens
- Balloon
- Candle
- Matches (you will light the candle when the student asks you to)
- Paper
- Clay
- Pencil
- Ruler

Lab Preparation

1. Print out copies of the student worksheets, lap practical, and quiz.
2. Have a tub of the materials in front of you at your desk. Kids will come up when called and demonstrate their knowledge using these materials.

Lesson

The students are taking two tests today: the quiz and the lab practical. The quiz takes about 20 minutes, and you'll find the answer key to make it easy to grade.

Lab Practical

Students will demonstrate individually that they know how to model certain parts of the body using scientific principles. While other kids are waiting for their turn, they will get started on their homework assignment. You get to decide whether they do their assignment individually or as a group.

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

Teacher's Answer Key

1. 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.)
2. What are the two main types of muscles? (voluntary and involuntary)
3. Give two examples of a muscle group. (Example: cardiac muscles, smooth muscles)
4. What is the smooth, hard, protective layer on the outside of bones called? (cortical bone)
5. What is the inside spongy, porous, honeycombed bone called? (cancellous bone)
6. Which body system is the heart a part of? (cardiovascular system) What are some of the jobs? (delivering nutrients and oxygen, disposing of waste, regulating body temperature, fighting disease, maintaining homeostasis)
7. Which body system are your lungs a part of? (respiratory system) What are some other parts in this system? (trachea, diaphragm, nose, mouth, etc.)
8. What is pH and how is it useful? (a measurable scale that lets us know how acidic or basic something is) What pH is considered acidic? (1-4)
9. 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.)
10. What do your kidneys do, and how do they do it? (The kidneys remove waste material, minerals, and fluids from the blood and put it in the urine by acting as a filter.)

Life Science 2 Quiz

Student Worksheet

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?

Life Science 2 Lab Practical

Teacher's Answer Key

This is your chance to see how well your students have picked up on important key concepts, and if there are any holes. Your students also will be working on their homework assignment as you do this test individually with the students.

Materials:

Double convex lens

- Balloon
- Candle
- Matches (you will light the candle when the student asks you to)
- Paper
- Piece of clay
- Pencil
- Ruler

Lab Practical: Ask the student *Note: Answers given in italics!*

- Design an experiment that shows how the shape of the eye will make people near- or far-sighted. *Blow up the balloon and insert the lens into the mouth of the balloon. The student will bring the balloon close to a lit candle and show the image of the candle that appears on the back of the balloon. Squish the balloon slightly on the top to make a near-sighted eyeball, and then gently push in the front and back of balloon to make it a far-sighted balloon.)*
- Design an experiment that shows how a first-class lever works, and also show where in your body you can find this type of lever. *(Student will balance the middle of the ruler on their finger and then play a piece of clay at one end, and then push down on the other end of the ruler to lift the clay like a see-saw or teeter-totter. The neck joint in the middle is the fulcrum, with load and effort on either side.)*

The Scientific Method

One of the problems kids have is how to experiment with their great ideas without getting lost in the jumble of result data. So often students will not have any clear ideas about what change caused which effect in their results! Students often have trouble communicating their ideas in ways that not only make sense but are also acceptable by science fairs or other technical competitions designed to get kids thinking like a real scientist. Another problem they face is struggling to apply the scientific method to their science project in school, for scout badges, or any other type of report where it's important that other folks know and understand their work.

The scientific method is widely used by formal science academia as well as scientific researchers. For most people, it's a real jump to figure out not only how to do a decent project, but also how to go about formulating a scientific question and investigate answers methodically like a real scientist. Presenting the results in a meaningful way via "exhibit board"… well, that's just more of a stretch that most kids just aren't ready for. There isn't a whole lot of useful information available on how to do it by the people who really know how. That's why I'm going to show you how useful and easy it is.

The scientific method is a series of 5 steps that scientists use to do their work. But, honestly, you use it every day, too! The five steps are Observation, Hypothesis, Test, Collect Data, and Report Results. That sounds pretty complicated, but don't worry, they are just big words. Let me tell you what these words mean and how to play with them.

Step 1: Observation means what do you see, or hear, or smell, or feel? What is it that you're looking at? Is that what it usually does? Is that what it did last time? What would happen if you tried something different with it? Observation is the beginning of scientific research. You have to see or touch or hear something before you can start to do stuff with it, right?

Step 2: Once you observe something, you can then form a hypothesis. All hypothesis really means is "guess." A hypothesis is an educated guess. Tonight at dinner, when someone asks you, "Do you want peas or carrots?" Say, "I hypothesize that I would like the carrots." Everyone will think you're a genius! Basically you're saying "I guess that I would like the carrots." Hypotheses aren't right or wrong, they are just your best guess.

Step 3: To see if your guess is correct, you need to do the next step in the scientific method: test. The test is just what it sounds like: running experiments to see whether or not your hypothesis is correct.

Step 4: As you do your tests, you need to collect data. That means collecting the numbers, the measurements, the times, the data of the experiment. Once you collect your data, you can take a look at it, or in other words, analyze it.

Step 5: Once you analyze your data you can report your results. That basically means tell someone about it. You can put your data in a chart or a graph or just shout it from the rooftops!

Here's a great way to remember the 5 steps. Remember the sentence "Orange Hippos Take Classes Regularly." The first letter in each word of that goofy sentence is the same as the first letter in each step of the scientific method. That's called a mnemonic device. Make up your own mnemonic devices to remember all sorts of stuff.

"OK, so that's what the words mean. How do I use that every day?"

Well, I'm glad you asked that question. If you had cereal for breakfast this morning, you did the scientific method. On the table you had a bowl of cereal with no milk in it. As you looked at your dry cereal, you made an observation, "I need milk!" At that point, you made a hypothesis, "There's milk in the fridge." You can't be sure there's milk in the fridge. Someone might have used it up. It might have gone bad. Aliens may have used it to gas up their milk-powered spaceship. You just don't know! So you have to do a test.

What would be a good test to see if there is milk in the fridge? Open the fridge! Now once you move the week-old spaghetti and the green Jell-O (at least you hope it's Jell-O) out of the way, you can see if there is milk or not. So you collect your data. There is milk or there isn't milk. Now you can finally report your results. If there is milk, you can happily pour it on your cereal. If there isn't any milk, you report your results by shouting, "Hey, Mom...We need milk!" Scientific method, not so hard is it?

You'll get familiar with the scientific method by doing the activities and experiments in your lessons. Most scientists don't use the *full* version of the scientific method, which actually includes several additional steps to the ones I've outlined above. You'll find the full-blown version of the scientific method in the back of this book. I've included a copy of a special project which won first prize at a science fair. You'll find this complete project explains every detail and how it uses the full version of the scientific method so you can see how to do it for yourself on any project you choose.

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

seizure – Period of unconsciousness, possibly including violent muscle movements

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