LIFE SCIENCE 1

PARENT/TEACHER'S GUIDE

Discover the science behind invisible life like plant structure, cell division, and genetics. Students will construct a water cycle terraqua column ecosystem, extract DNA, grow a carnivorous greenhouse, track traits, learn how to use a compound microscope, and more.

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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! I hope you will find this helpful in preparing to teach your students, exhaustibly 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 24 lessons outlined to take you from an introduction of Life Science on through several advanced topics 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 in each section. 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. For ten lab groups, an easy way to keep track of your materials is to give each group a number from one to ten, and make up ten separate lab kits using small plastic tubs or baskets. Put one number on each item and fill each tub with the materials listed below. Label the tubs with the section name, like *Life Science Study Kit* and you will have an easy way to keep track of the materials and build accountability into the program for the kids. Copy these lists and stick them in the bin for easy tracking. Feel free to reuse items between lessons and unit sections. Most materials are reusable year after year.

Parts numbers are from www.hometrainingtools.com unless noted.

aluminum foil
bottle caps (4)
bucket
candle and matches (with adult help)
cardboard
carrots (5)
celery stalks with leaves
clay
clear plastic tub with lid
clothespins
coffee filter
coins
compound microscope (if you need a recommendation for purchasing: MI-4100STD)
cookie sheet
cotton ball
cotton string (about 5 feet)
cover slips (5) (MS-SLIDCV)
cups or water glasses
dishwashing detergent
drill with drill bit, with adult help
dry beans (about a cup)
eye dropper (3) (CE-DROPPER)
fast-growing plant seeds (radish, grass, turnips)
flexible rubber tubing, 1-2 feet (CE-TUBERU2)
food coloring
funnel (CE-FUNNEL)
glass jar with a lid
iodine (CH-IODINE)
isopropyl alcohol, 91%
light bulb in a lamp
microscope slides (MS-SLIDEPL)
onion (the root tip, not the onion itself)
paper
paper grocery bag
paper towels
penny
plants or seeds
plastic container with a snap-lid (BE-INVIAL3)
plastic wrap
pond water sample
potato
predators: spiders OR praying mantis OR carnivorous plants
razor, with adult help
red worms (20)
rubber bands (some large and strong)
ruler
salt
sand (regular sandbox sand)
scale for weighing your plant
scissors
soda bottles (2-liter)
soil
spoon
spray bottle with mineral free water in it
stopwatch
strand of hair
straws, flexible
sugar
tablespoons of salt (3)
tape
toothpicks or tweezers
tweezers
wire mesh (¼ inch), like for window screens
yeast

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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 that 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 eyeglasses don't provide.

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.

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 lets 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 your students 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 learn 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, and 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 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 all 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 manifold in the future.

Educational Goals for Life Science 1

You already know that plants need water to survive. But how do they actually drink that water, take in nutrients and help the environment? In these experiments, you will learn how water travels through a plant, and you will get to try to make the water go faster and slower! You'll explore how water and the atmosphere are both polluted and purified, and investigate how plants and soil help with both of these. You will also learn that plants have many parts that perform different functions, and you will test how much stuff can pass through a membrane.

In this lab, you'll also get to observe and investigate the habits and behaviors of your favorite animals by building different tools. If you're fascinated by worms but frustrated that you can't see them do their work underground, then the worm column is just the ticket for you. You will also observe an aquarium, a decomposition chamber with fruit flies or worms, and a predator chamber, with water that flows through all sections. This is a great way to see how the water cycle, insects, plants, soil, and marine animals all work together and interact. Photosynthesis is a process where light energy is changed into chemical energy, and you will see why it is important to animals as well.

Here are the scientific concepts:

- Select and use appropriate tools and technology (including calculators, computers, balances, spring scales, microscopes, and binoculars) to perform tests, collect data, and display data.
- Different plants and animals inhabit different kinds of environments and have external features that help them thrive in different kinds of places.
- Plants and animals both need water; animals need food, and plants need light.
- Animals eat plants or other animals for food and may also use plants or even other animals for shelter and nesting.
- Roots are associated with the intake of water and soil nutrients, green leaves with making food from sunlight.
- Many characteristics of an organism are inherited from the parents. Some characteristics are caused by, or influenced by, the environment.
- The germination, growth, and development of plants can be affected by light, gravity, touch, or environmental stress.
- Plants and animals have structures that serve different functions in growth, survival, and reproduction.
- Producers and consumers (herbivores, carnivores, omnivores, and decomposers) are related in food chains and food webs, and may compete with each other for resources in an ecosystem.
- Many multicellular organisms have specialized structures to support the transport of materials.
- How sugar, water, and minerals are transported in a vascular plant.
- Plants use carbon dioxide (CO_2) and energy from sunlight to build molecules of sugar and release oxygen.
- Energy entering ecosystems as sunlight is transferred by producers into chemical energy through photosynthesis, and then from organism to organism in food webs.
- Over time, matter is transferred from one organism to others in the food web, and between organisms and the physical environment.
- The number and types of organisms an ecosystem can support depends on the resources available and abiotic factors, such as quantity of light and water, range of temperatures, and soil composition.
- Cells function similarly in all living organisms.
- The characteristics that distinguish plant cells from animal cells, including chloroplasts and cell walls.

- Mitochondria liberate energy for the work that cells do, and chloroplasts capture sunlight energy for photosynthesis.
- Cells divide to increase their numbers through a process of mitosis, which results in two daughter cells with identical sets of chromosomes.
- As multicellular organisms develop, their cells differentiate.
- An inherited trait can be determined by one or more genes.
- Plant and animal cells contain many thousands of different genes, and typically have two copies of every gene. The two copies (or alleles) of the gene may or may not be identical, and one may be dominant in determining the phenotype while the other is recessive.
- DNA is the genetic material of living organisms, and is located in the chromosomes of each cell.
- Living organisms are made of molecules largely consisting of carbon, hydrogen, nitrogen, oxygen, phosphorus and sulfur.

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

- Design and build a water cycle column, a terraqua column, an insect aspirator, a Berlese funnel, a waterscope, a hydrometer, an eco column, and a carnivorous greenhouse.
- Know how to demonstrate how to use and care for a microscope, how to mount slides, and how to record data viewed through a microscope.
- Understand how to determine the parts and functions of plants, the effects of osmosis, the stages of mitosis, the components of an eco system, the characteristics of worms and the genotypes and phenotypes of offspring.
- 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: How to Use a Microscope

Teacher Section

Overview Welcome to our unit on microscopes! We're going to learn how to use our microscope to make things appear larger so we can study them more easily. If you've ever wondered what you're eating for dinner, how many toes ants have, or if caterpillars have armpits, then this is the lab for you. We're going to discover how to prepare slides, handle a compound microscope, and have a fun time peeking into the tiny world of microorganisms.

This lab is focused on *how* to work a microscope and the techniques for preparing slides. Figuring out exactly *what* you're looking at is totally up to you. A trip to the library or local college student lab might be a very good investment of your time, once you've learned how to handle the basics we're going to cover here.

How to the lenses work to make objects larger? We're going to take a closer look at optics, magnification, lenses, and how to draw what you see with this lesson.

Suggested Time 45-75 minutes

Objectives Students will learn the proper use and care of a microscope as they learn to prepare dry mount, wet mount, heat fix and stain microscope slides. They will also learn how to record what they see through a microscope lens.

Materials (per lab group)

- microscope
- slides
- coverslips
- tape
- a penny
- the letter "e"
- strand of hair
- scissors
- prepared slides (one per microscope)

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the videos for this experiment to prepare for teaching this class.
4. Set up microscopes around the perimeter of the room with prepared slides. Adjust the focus so the students only have to look through the eyepiece. If your slide is labeled, put a piece of tape over it because the students are going to peek through the microscope and guess what they are looking at. Label each microscope with a number or letter so you can reveal which scope has which specimen at the end of the lab. Make sure you have one microscope set up per lab group.
5. A lot of 12pt font letter "e" cut out for the students to use, one per lab group.

Background Lesson Reading

A compound microscope is really just a set of lenses stacked so they work together to make things look bigger. For example, if you're using a 10x eyepiece (where your eye looks into) and a 40x objective (the lens near the slide), then you're using a 400x power setting.

Not only is it important to learn how to work the scope, but you need to learn how to sketch what you see, or the information on the slide is only useful to one person – you. Make sure you always add a border (so your viewer knows where your drawing starts and ends), title (so you know what you were looking at), power of magnification (so you can do it again if needed), and keep your proportions accurate when you draw the image.

You can use either a dry or wet mount to get your specimens ready for viewing. A dry mount doesn't use any chemicals, water, or glue… and sometimes not even a coverslip. Just stick it on the slide and you're good to go. This is a great place to start when first using a scope.

Anatomy of Microscope

Nose? Objective? Stage? What kind of class *is* this? Well, some of the names may sound a bit odd, but this video will show you what they are and how they are used. As you watch the video, touch the corresponding part of your microscope to get a feel for how it works.

NOTE: Be very careful NOT to raise the stage too high or you'll crack the objective lens! Always leave a space between the stage and the lens!! Anytime you use the coarse adjustment knob, always look at the stage itself, NOT through the eyepiece (for this very reason). When you use the fine adjustment knob, that's when you look through the eyepiece.

Care and Cleaning

1. Pick up the microscope with two hands. Always grab the arm with one hand and the legs (base) with the other.

2. Don't touch the lenses with your fingers. The oil on your fingers will smudge and etch the lenses. Use an optical wipe if you must clean the lenses. Steer clear of toilet paper and paper towels – they will scratch your lenses.

3. When you're done with your scope for the day, reset it so that it's on the lowest power of magnification and lower the stage to the lowest position. Cover it with your dust cover or place it in its case.

Preparing a Dry Mount

This is simplest form of slide preparation! All you need to do is place it on the slide, use a coverslip (and you don't even have to do that if it's too bumpy), and take a look through the eyepiece. No water, stains, or glue required.

You know that this is the mount type you need when your specimen doesn't require water to live. Good examples of things you can try are cloth fibers (the image here is of cotton thread at 40X magnification), wool, human hair, salt, and sugar. It's especially fun to mix up salt and sugar first, and then look at it under the scope to see if you can tell the difference.

Lesson

1. Introduce the microscope: Say: "*Today we are going to begin work with microscopes. They are very important to scientists. Does anyone know why?"* Listen to a few answers, and quickly acknowledge any that seem appropriate (such as –"to look at things" "to examine things," etc). If students are unfamiliar with microscope usage, say, "In science, we use microscopes to spy on things. We spy on really tiny things, or we spy on a tiny part of a big thing."
2. Begin the Anatomy of a Microscope: Say: "*To use a microscope, we are first going to learn what the parts are called. We are going to learn the "body parts" of a microscope."*
3. Have a microscope in plain view for all to see, or have a picture of a microscope on the projector. Point to the following parts, and have them repeat the word after you. Check understanding every couple of terms by pointing to a part and having them quickly name it.

    - eyepiece
    - coarse adjustment knob
    - fine adjustment knob
    - mirror (or lamp)
    - diaphragm
    - stage
    - aperture
    - objective lenses
    - arm
    - legs
    - nose
    - body

4. Play "Simon Says" with a microscope. Divide the class into 2 groups (more if there are more students), and one student from each group plays for that group. Have one microscope per group at the front of the room, so that just the student playing runs up to the microscope and touches the appropriate part (or just runs up and stands next to the microscope if "Simon didn't say.") Switch players as you like, either at each command, or you can switch after a few commands.
5. Ask: "*If I want to look at someone or something, is it easier to see them through a door or through window?"* Say: "*That's right! Through a window."*
6. Explain: "*When we want to examine things through a microscope, we need to put the thing in a window we call a slide. It is actually a sandwich, and the top piece is called the cover slip. They are see through, so we can see what's on the slide.*
7. Ask: "*If I can't see very well, what do I usually need to see better?"* Say: *"That's right! A pair of glasses or contact lenses."* Explain: "*A Microscope is like a pair of glasses, but the lenses are stacked on top of each other."*
8. Explain: *"If the first lens magnifies the object 5 times, and the second lens magnifies 10 times, I actually see the object 50 times closer that I could with my own eyes. That is because the 10 times lens magnifies the 5 times lens 10 times."* Write 5 x 10=50 on the board.
9. Check for understanding :*"If I have a 4 times lens and a 10 times lens, what is the magnification?"* Say *"That's right! 4x10 or 40 times!"*
10. Ask "*Is it a good idea for me to carry my eye glasses in between all of my textbooks? No, because they would crack. Similarly, there is a special way we need to handle and care for a microscope, so it doesn't break."*

11. Explain and write on the board:
    1. *Pick up the microscope with two hands: one hand on the bottom.*
    2. *Do not touch the lenses with your fingers or a paper towel.*
    3. *When you are finished with it for the day, reset the magnification to the lowest setting, and cover it with the dust cover.*
    4. *When you adjust the coarse adjustment knob, you must be looking at the stage, not through the eyepiece. Otherwise, the slide and lens may crack.*
12. Go over each rule again, this time modeling with a microscope and pointing out what each rule is talking about. Only you, the teacher, should have a microscope at this point.
13. Check understanding: Show an incorrect way to pick up the microscope and a correct way. Ask the class which way is right. Repeat a few times, covering each rule at least twice. Model common mistakes, so students can see what is not right, and what is right when handling a microscope.
14. Now you're going to let the kids loose around the room to look through the microscopes you've already set up. Break the kids into their lab groups and let them know that they have one minute to not only look through the eyepiece, but also come to an agreement as a team as to what they are looking at. If you are using science journals, take them out now to record their observations. Otherwise the students can simply use a sheet of paper. After the students finish, you can reveal what was in each microscope. Gather them back to you so you can explain the rest of the lab before letting them loose again.

When you've completed this part of the lab, it's time to learn how to prepare a *Dry Mount* slide.

15. Say: *"Now that you know what a microscope is, you know the parts of a microscope, and you know how to use and care for a microscope, we are going to learn how to prepare a slide, to see the specimen we want to look at."*
16. Remind students: "*When we want to look at something, it is easier to look at it through a window than a door. For each specimen we want to look at, we prepare as special window called a slide. We cover the specimen with a cover slip to protect it."*
17. Hold a slide flat. Tell a student you would like to examine a strand of their hair. Have them rip one out, and come up and put it on the slide. Cover with a cover slip, so as to model a dry mount.
18. Explain: "*This is the easiest way to prepare a slide. It is called a dry mount, because we just have the object with no liquid."* Ask for a couple of other items to examine (a fingernail, a thread), and have one student mount it on the slide in your hand each time, for everyone to see.
19. Ask for a penny (or other bumpy/bulky item). When the student places it on the slide, do not cover it. Say: *"Sometimes, the object is too thick or bumpy for a cover slip, so we don't need one."*
20. Show a strand of dry spaghetti. Put it on the slide and watch it roll around a bit. Explain: *"If the object won't stay still, you may tape it on either end when you dry mount it."*
21. Explain: "*When scientists look at things under the microscope, they share it with others. They do so by drawing what they see under the microscope. When we draw what we see, we need to make it like a picture on the wall. It must have:*
    1. *A border/frame.* Draw a circle on the board.
    2. *A title* Write "Student's hair."
    3. *The magnification power* Write 100x (remember to multiply the eyepiece mag power by the coarse knob magnification power.)
    4. *It is very important to draw what you see on the scale you see it.* "
22. Check for Understanding: Draw a sample drawing on the board, with one element missing. Ask what's missing.

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 a look at the eyepiece of your microscope. Do you see a number followed by an X? That tells you the magnification of your microscope. If it's a 10X, then it will make objects appear ten times larger than usual.
4. Peek at the objective lenses. They're on the nose of the microscope, and there's usually 3 or 4 of them. Do you see the little numbers printed on the side of the lenses, also followed by an X? Find the one that says 4. if you look through just that lens by itself, objects will appear 4 times as large. However, it's in a microscope, so you're actually looking through *two* lenses when you use the microscope. What that means is that you need to multiply this number by the eyepiece magnification (in our example, it's 4 * 10 = 40) to get the total power of magnification when you use the microscope on this power setting. **It's 40X when you use the 10X eyepiece and 4X objective.** So objects are going to appear 40 times larger than in real life.
5. Practice these with your microscope . Fill out the table to figure out how to set the lenses for the different magnification powers:

Eyepiece	Objective	Total Magnification
10X	4X	
10X		100X
	40X	400X
10X		1000X

6. Carefully cut a single letter (like an "a" or "e") from your lab sheet.
7. Use your tweezers to place the small letter on a slide and place a coverslip over it (be careful with these – they are thin pieces of glass that break easily!) If your letter slides around, add a drop of water and it should stick to the slide.

8. Lower the stage to the lowest setting using the coarse adjustment knob (look at the stage when you do this, not through the eyepiece).
9. Place your slide in the stage clips.
10. Turn the diaphragm to the largest hole setting (open the iris all the way).
11. Move the nose so that the lowest power objective lens is the one you're using.
12. Bring the stage up halfway and peek through the eyepiece.
13. If you're using a mirror, rotate the mirror as you look through the eyepiece until you find the brightest spot. You'll probably only see a fuzzy patch, but you should be able to tell bright from dim at this point.

14. Use the coarse adjust to move the stage slowly up to bring it into rough focus. If you've lowered the stage all the way in step 7, you'll see it pop into focus easily. (Be careful you don't ram the stage into the lens!)
15. Use the fine adjust to bring it into sharp focus. What do you see?
16. Draw a picture of that the letter looks like under the lowest power setting in your first circle and label it 'right side up'. Then give the slide a half turn and draw another picture in a new circle. Label this one 'upside-down'.
17. If you're using a mechanical stage (which we highly recommend), twist one of the knobs so that the slide physically moves to the right as you look from the side (not through the eyepiece) of the microscope. If you're using stage clips, just nudge the slide to the right with your finger. Now peek through the eyepiece as you move the slide to the right – which way does your letter move?
18. Now do the same for the other direction – make the slide move toward you. Which way does the letter appear to move when you look through the eyepiece?
19. What effect do the two lenses have on the letter image as you move it around?
20. Look back at your two drawings above. Let's make them so they are totally useful, the way scientists label their own sketches. We're going to add a border, title, power of magnification, and more to get you in the habit of labeling correctly. Here's how you do it:
    1. <u>Border</u> You need to frame the picture so the person looking at it knows where the image starts and ends. Use a water glass to help make a perfect circle every time. When I sketch at the scope, I'll fill an entire page with circles before I start so I can quickly move from image to image as I switch slides.
    2. <u>Title</u> What *IS* it? Paramecia, goat boogers, or just a dirty slide? Let everyone (including you!) know what it is by writing exactly what it is. You can use bold lettering or underline to keep it separate from any notes you take nearby.
    3. <u>Magnification Power</u> This is particularly useful for later, if you need to come back and reference the image. You'll be quickly and easily able to duplicate your own experiment again and again, because you know how it was done.
    4. <u>Proportions</u> This is where you need to draw only what you see. Don't make the image larger or smaller – just draw exactly what you see.

21. Pull a hair from your head and lay it on a slide. If it's super-curly, use a bit of tape at either end, stretching it along the length of the slide. Keep the tape near the ends so it doesn't come into your field of view when you look through the microscope.
22. Lower the stage to the lowest setting and rotate the nose piece to the lowest magnification power.
23. Place the slide on the stage in your clips.
24. Focus the hair by looking through the eyepiece and slowly turning the coarse adjustment knob. When you're close to focus, switch to the fine adjustment knob until it pops into sharp view.
25. Sketch what you see (don't forget the title and magnification power!)
26. When you're done, lower the stage all the way and insert a new slide… and repeat. Find at least six things to look at. We're not only learning how to look and draw, but hammering a habit of how to handle the scope properly, so do as many as you can find.
27. Don't forget to check the windowsills for interesting bits. Use baby food jars or film canisters to collect your specimens in and keep them safe until you need them.
28. TIP: If you want to keep your specimen on the slide for a couple of months, use a drop of super glue and lay a coverslip down on top, pressing gently using a toothpick (not your fingers) to get the air bubbles out. Let dry.

Exercises

1. Why do we use microscopes? (To see into the tiny world of microorganisms)
2. What's the highest power of magnification on your microscope? Lowest?(answers may vary. Make sure students calculate magnification power properly: multiply the objective lens by the eyepiece power)
3. Where are the two places you should NEVER touch on your microscope?(the glass part of the objective lens or the glass part of the eyepiece).
4. Fill in the blanks with the appropriate word to describe care and cleaning of your microscope:

fingers	lowest	hands	
arm	toilet paper	legs	dust cover

1\. Pick up the microscope with two __hands_. Always grab the __arm__ with one hand and the __legs__(base) with the other.

2\. Don't touch the lenses with your _fingers_. The oil will smudge and etch the lenses. Use an optical wipe if you must clean the lenses. Steer clear of __toilet paper_ and paper towels – they will scratch your lenses.

3\. When you're done with your scope for the day, reset it so that it's on the _lowest_ power of magnification and lower the stage to the lowest position. Cover it with your _dust cover_ or place it in its case.

5. What things must be present on your drawing so others know what they're looking at? (a border, a title, the magnification power, proper proportions).
6. What's the proper way to use the coarse adjustment knob so you don't crack the objective lens? (Look at the stage as you raise it with the coarse adjustment knob, and don't allow the stage to touch the objective lens.)
7. List three possible combination of eyepiece and objective lenses if the power of magnification is 100X. (10x and 10x; 4x and 25x; 5x and 20x)
8. Briefly describe how to dry mount a slide. (Put the object on the slide. Tape it down on the sides if it curls up too much. Put a cover slip on it, if the object is not too bumpy or bulky).
9. How could you view a copper penny with your microscope? (Put the penny on a slide without a cover slip. Tape it down on the sides.)

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: How to Use a Microscope

Student Worksheet

Name____

Overview Welcome to our unit on microscopes! We're going to learn how to use our microscope to make things appear larger so we can study them more easily. If you've ever wondered what you're eating for dinner, how many toes ants have, or if caterpillars have armpits, then this is the lab for you. How to the lenses work to make objects larger? We're going to take a closer look at optics, magnification, lenses, and how to draw what you see with this lesson.

What to Learn The compound microscope is a set of lenses stacked so they work together to make things look bigger. For example, if you're using a 10x eyepiece (where your eye looks into) and a 40x objective (the lens near the slide), then you're using a 400x power setting. You use a dry to get your specimens ready for viewing.

Materials

- microscope
- slides
- coverslips
- tape
- a penny
- the letter "e"
- scissors
- an object to dry mount, such as a strand of hair

Lab Time

1. Your first task is to take a peek through a microscope and see if you can figure out what you are looking at. Record your guess in the data table below. You'll only get to spend 90 seconds on this before you move onto the next microscope. Everyone writes down their answers individually, and then discusses it and comes up with a final group conclusion what's on each slide.

What Is It? Data Table

Microscope #	What do you observe?

2. When you've completed this table, come back to your teacher who will demonstrate the next part of the lab for you.

3. Take a look at the eyepiece of your microscope. Do you see a number followed by an X? That tells you the magnification of your microscope. If it's a 10X, then it will make objects appear ten times larger than usual.
4. Peek at the objective lenses. They're on the nose of the microscope, and there's usually 3 or 4 of them. Do you see the little numbers printed on the side of the lenses, also followed by an X? What is that number on your microscope? ___________________________
5. Here are the settings on a microscope. Fill out the table to figure out how to set the lenses for the different magnification powers:

Eyepiece	Objective	Total Magnification
10X	4X	
10X		100X
	40X	400X
10X		1000X

6. Carefully cut a single letter (like an "a" or "e") from your lab sheet here → a e
7. Use your tweezers to place the small letter on a slide and place a coverslip over it (be careful with these – they are thin pieces of glass that break easily!) If your letter slides around, add a drop of water and it should stick to the slide.
8. Lower the stage to the lowest setting using the coarse adjustment knob (look at the *stage* when you do this, not through the eyepiece).
9. Place your slide in the stage clips.
10. Turn the diaphragm to the largest hole setting (open the iris all the way).
11. Move the nose so that the lowest power objective lens is the one you're using.
12. Bring the stage up halfway and peek through the eyepiece.
13. If you're using a mirror, rotate the mirror as you look through the eyepiece until you find the brightest spot. You'll probably only see a fuzzy patch, but you should be able to tell bright from dim at this point.
14. Use the coarse adjust to move the stage slowly up to bring it into rough focus. If you've lowered the stage all the way, you'll see it pop into focus easily. (Be careful you don't ram the stage into the lens!)
15. Use the fine adjust to bring it into sharp focus.
16. Draw a picture of that the letter looks like under the lowest power setting in your first circle (see *Microscope Lab Data* below) and label it 'right side up'.
17. Give the slide a half turn and draw another picture in a new circle. Label this one 'upside-down'.
18. If you're using a mechanical stage, twist one of the knobs so that the slide physically moves to the right as you look from the side (not through the eyepiece) of the microscope. If you're using stage clips, just nudge the slide to the right with your finger.

19. Now peek through the eyepiece as you move the slide to the right – which way does your letter move?

____

20. Now do the same for the other direction – make the slide move toward you. Which way does the letter appear to move when you look through the eyepiece?

____

21. What effect do the two lenses have on the letter image as you move it around?

____

22. Look back at your two drawings. Let's make them so they are totally useful, the way scientists label their own sketches. We're going to add a border, title, power of magnification, and more to get you in the habit of labeling correctly. Here's how you do it:

    a. **Border** You need to frame the picture so the person looking at it knows where the image starts and ends. Use a water glass to help make a perfect circle every time. When I sketch at the scope, I'll fill an entire page with circles before I start so I can quickly move from image to image as I switch slides.
    b. **Title** What *IS* it? Paramecia, goat boogers, or just a dirty slide? Let everyone (including you!) know what it is by writing exactly what it is. You can use bold lettering or underline to keep it separate from any notes you take nearby.
    c. **Magnification Power** This is particularly useful for later, if you need to come back and reference the image. You'll be quickly and easily able to duplicate your own experiment again and again, because you know how it was done.
    d. **Proportions** This is where you need to draw only what you see. Don't make the image larger or smaller – just draw exactly what you see.

23. Pull a hair from your head and lay it on a slide. If it's super-curly, use a bit of tape at either end, stretching it along the length of the slide. Keep the tape near the ends so it doesn't come into your field of view when you look through the microscope.
24. Lower the stage to the lowest setting and rotate the nose piece to the lowest magnification power.
25. Place the slide on the stage in your clips.
26. Focus the hair by looking through the eyepiece and slowly turning the coarse adjustment knob. When you're close to focus, switch to the fine adjustment knob until it pops into sharp view.
27. Sketch what you see (don't forget the title and mag power!) in the third circle in *Microscope Lab Data* below*.*
28. Stop and look around the classroom. Find at least six things to look at. We're not only learning how to look and draw, but hammering a habit of how to handle the scope properly, so do as many as you can find. Don't forget to check the windowsills for interesting bits. Use baby food jars or film canisters to collect your specimens in and keep them safe until you need them.
29. Lower the stage all the way and insert a new slide… and repeat this process for all six specimens.

Microscope Lab Data

Microscope Lab Data

Exercises Answer the questions below:

1. Why do we use microscopes?

2. What's the highest power of magnification on your microscope? Lowest?

3. Where are the two places you should NEVER touch on your microscope?

4. Fill in the blanks with the appropriate word to describe care and cleaning of your microscope:

fingers	lowest	hands	
arm	toilet paper	legs	dust cover

1. Pick up the microscope with two _______. Always grab the ________with one hand and the ______(base) with the other.

2. Don't touch the lenses with your ________. The oil will smudge and etch the lenses. Use an optical wipe if you must clean the lenses. Steer clear of ___________ and paper towels – they will scratch your lenses.

3. When you're done with your scope for the day, reset it so that it's on the ________ power of magnification and lower the stage to the lowest position. Cover it with your _________ or place it in its case.

5. What things must be present on your drawing so others know what they're looking at?

6. What's the proper way to use the coarse adjustment knob so you don't crack the objective lens?

7. List three possible combination of eyepiece and objective lenses if the power of magnification is 100X.

8. Briefly describe how to dry mount a slide.

9. How could you view a copper penny with your microscope?

Lesson # 2: Wet Mount and Staining

Teacher Section

Overview Anytime a specimen needs water to live, you'll need to prepare a wet mount slide. This is especially useful for looking at pond water (or scum), plants, protists (single-cell animals), mold, etc. When you keep your specimen alive in their environment, you not only get to observe it, but also how it eats, lives, breathes, and interacts in its environment. If your critter is hard to see, you can use a dye to bring out the cell structure and make it easier to view.

Suggested Time 30-45 minutes

Objectives Students will learn how to prepare a wet mount slide and use an iodine to stain specimens that are too translucent to see.

Materials (per lab group)

- 20mL sample of pond water
- microscope
- slides
- cover slips
- tweezers
- medicine dropper (disposable)
- a translucent specimen, such as a piece of onion and elodea leaf
- iodine (you can use regular, non-clear iodine from the drug store)
- Protoslo (optional)

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 wet mount is used for living things, like the stuff found in pond scum. By keeping the organisms wet (and in their environment), you can watch how they move, eat, breathe, and interact. When specimens are hard to see (even after adjusting your diaphragm) you can use staining (like Lugol's stain or dark iodine) to add contrast and bring it into view. Protoslo can be used when specimens move too fast to view.

If your critter is hard to see, you can use a dye to bring out the cell structure and make it easier to view. There are lots of different types of stains, depending on what you're looking at.

The procedure is simple, although kids will probably stain not only their specimens, but the table and their fingers, too. Protect your surfaces with a plastic tablecloth and use gloves if you want to.

Lesson

1. Explain and ask: *"When we want to look at something with a microscope, we put it on a slide. But what if we want to look at something that is wet, like some pond water or beach water or even saliva?"*
2. Take a few student responses and then explain: *"We put it on the slide, just like with a dry specimen. But, we only put one drop of the liquid; we don't want too much, or it will spill off of the slide."*
3. Explain and model: "*We also need to make sure to put a cover slip on it, but we do so carefully. Start with one side only, and place it on the drop. Make sure you are holding the other end up at an angle."*
4. Explain and model: *"Slowly lower the cover slip over the drop, so the drop spreads out. There should be no air bubbles."*
5. Explain and model: *"If there are, we may be able to fix that by gently pressing them out. If we squish out too much of our sample, we may need to just start over."*
6. Have two or three students, one at a time, practice preparing a wet mount in front of the class. Show each slide around to the class, so they can clearly see properly and improperly prepared wet mounts.
7. Draw a yellow line on the white board and a black one. Ask students which is easier to see. Say: *"That's right! The darker one is easier to see?"*
8. Explain: "*We are going to darken the specimens that are too light, so that we can see them better."*
9. Explain and model: "*When the specimen is translucent, like the skin of an onion, we need to stain it so we can se it more clearly. To stain, we first add a drop of water to the onion peel, and place the cover slip on. Then we add a drop of iodine on one side of the cover slip, while we hold a folded tissue on the other side."*
10. Have at least one student stain a slide, and show the whole class. Point out what was right about it, and ways to improve the stain, if appropriate.

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 slide on the table.
4. Fill the eyedropper with pond water and place a drop on the slide.
5. Place the edge of the cover slip on the pond water drop, holding the other edge up at an angle. Slowly lower the end down so that the drop spreads out. You want a very thin film to lay on the slide without any air bubbles or excess water squirting out. If you go have bubbles, *gently* press down on the cover slip to squish them out or start over.
6. Take time practicing this – you want the water only under the coverslip. Dab away excess water that's not under the slide with a paper towel.
7. Lower the stage to the lowest setting and rotate the nose piece to the lowest magnification power.
8. Place the slide on the stage in your clips.
9. Focus by looking through the eyepiece and slowly turning the coarse adjustment knob. When you're close to focus, switch to the fine adjustment knob until it pops into sharp view.
10. Adjust the light level to get the greatest contrast so you can see better.
11. Move the slide around (this is where a mechanical stage is wonderful to have) until you spot something interesting. Place it in the center of your field of view, and switch magnification power to find a great view (not too close, not too far away). Adjust your focus as needed.
12. Sketch what you see (don't forget the title and magnification power!)
13. When you're done, lower the stage all the way and insert a new slide… and repeat.
14. NOTE: If the critters you're looking at move too fast, add a drop of *Protoslo* to the edge of your slide to slow them down (by numbing them). The Protoslo will work its way under the cover slip.

15. Fill a container with water and add a small piece of elodea leaf and onion. You'll want the onion to be a thin slice, no more than a quarter of an inch thick.
16. Put a fresh slide on the table. Using tweezers, pull off a thin layer of onion (use a layer from the middle, not the top) and place it on your slide. Gently stretch out the wrinkles (use a toothpick or tweezers) and add a small drop of water and cover with a cover slip. Take a peek at what your specimen looks like on low power – do you notice it's hard to see much? Draw what you see on your data sheet.
17. Now increase the power and look again. Draw a new sketch.
18. Now we're going to highlight the cell structure using iodine. Lugol's is also iodine, but the regular brown stuff from the drug store works, too. Grab a bottle of the one you're going to use.
19. To stain the specimen, we're going to add the stain to one side of the cover slip and wick away the water from the other side. Use a folded piece of tissue paper and touch it lightly to one side of the cover slip as you add a single drop of stain to the other side. When the stain has flowed through the entire specimen, take a peek and draw what you see in a fresh circle.
20. Do the same thing with the elodea leaf. And anything else plant-based from your backyard. Or refrigerator. Draw what you see and don't forget to label it with a title and power of magnification!

Exercises

1. Why do we use a wet mount slide? (to observe specimens that need water to live)
2. Give one example of a specimen that would use a wet mount slide? (pond scum)
3. How do you prepare a wet mount slide? (Put a drop of water on the slide. Put one end of the cover slip on the drop of water and slowly lower the other end. Gently press out any air bubbles and dab away any excess water that spilled out of the cover slip.)
4. Why do we stain specimens? (To view specimens that are too difficult to see because they are see through)
5. Give one example of a specimen that would use a stain. (An onion peel)
6. What type of stain can we use (give at least one example). (Iodine)

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: Wet Mount and Staining

Student Worksheet

Name____

Overview

Anytime you have a specimen that needs water to live, you'll need to prepare a wet mount slide. This is especially useful for looking at pond water (or scum), plants, protists (single-cell animals), mold, etc. If your critter is hard to see, you can use a dye to make it easier to view.

What to Learn

Some specimens needs water to live, so you'll need to keep them moist with a wet mount slide. When you keep your specimen alive in their environment, you not only get to observe it, but also how it eats, lives, breathes, and interacts in its environment. If your critter is hard to see, you can use a dye such as iodine to stain the cell and bring out its structure, making it easier to view.

Materials

- 20mL sample of pond water
- microscope
- slides
- cover slips
- tweezers
- medicine dropper (disposable)
- a translucent specimen, such as a piece of onion and elodea leaf
- iodine (you can use regular, non-clear iodine from the drug store)
- Protoslo (optional)

Lab Time

1. Place a slide on the table.
2. Fill the eyedropper with pond water and place a drop on the slide.
3. Place the edge of the cover slip on the pond water drop, holding the other edge up at an angle. Slowly lower the end down so that the drop spreads out. You want a very thin film to lay on the slide without any air bubbles or excess water squirting out. If you go have bubbles, *gently* press down on the cover slip to squish them out or start over.
4. Take time practicing this – you want the water only under the coverslip. Dab away excess water that's not under the slide with a paper towel.
5. Lower the stage to the lowest setting and rotate the nose piece to the lowest magnification power.
6. Place the slide on the stage in your clips.
7. Focus by looking through the eyepiece and slowly turning the coarse adjustment knob. When you're close to focus, switch to the fine adjustment knob until it pops into sharp view.

8. Adjust the light level to get the greatest contrast so you can see better.
9. Move the slide around (this is where a mechanical stage is wonderful to have) until you spot something interesting. Place it in the center of your field of view, and switch magnification power to find a great view (not too close, not too far away). Adjust your focus as needed.
10. Sketch what you see (don't forget the title and mag power!)
11. When you're done, lower the stage all the way and insert a new slide… and repeat. Find at least six *more* things to look at. We're not only learning how to look and draw, but hammering a habit of how to handle the scope properly, so do as many as you can find.
12. NOTE: If the critters you're looking at move too fast, add a drop of *Protoslo* to the edge of your slide to slow them down (by numbing them). The Protoslo will work its way under the cover slip.
13. Fill a container with water and add a small piece of elodea leaf and onion. You'll want the onion to be a thin slice, no more than a quarter of an inch thick.
14. Put a fresh slide on the table. Using tweezers, pull off a thin layer of onion (use a layer from the middle, not the top) and place it on your slide. Gently stretch out the wrinkles (use a toothpick or tweezers) and add a small drop of water and cover with a cover slip. Take a peek at what your specimen looks like on low power – do you notice it's hard to see much? Draw what you see in your data table.
15. Now increase the power and look again. Draw a new sketch in data table.
16. Now we're going to highlight the cell structure using iodine. Lugol's is also iodine, but the regular brown stuff from the drug store works, too. Grab a bottle of the one you're going to use.
17. To stain the specimen, we're going to add the stain to one side of the cover slip and wick away the water from the other side. Use a folded piece of tissue paper and touch it lightly to one side of the cover slip as you add a single drop of stain to the other side. When the stain has flowed through the entire specimen, take a peek and draw what you see in a fresh circle.
18. Do the same thing with the elodea leaf. And anything else plant-based from your backyard. Or refrigerator. Draw what you see and don't forget to label it with a title and power of magnification!

Wet Mount Microscope Lab Data

Wet Mount Microscope Lab Data

Exercises Answer the questions below:

1. Why do we use a wet mount slide?

2. Give one example of a specimen that would use a wet mount slide?

3. How do you prepare a wet mount slide?

4. Why do we stain specimens?

5. Give one example of a specimen that would use a stain.

6. What type of stain can we use (give at least one example).

Lesson #3: Heat Fixes

Teacher Section

Overview If you tried looking at animal cells already, you know that they wiggle and squirm all over the place. And if you tried looking when using the staining technique, you know it only makes things *worse.* The heat fix technique is the one you want to use to nail your specimen to the slide and also stain it to bring out the cell structure and nuclei. This is the way scientists can look at things like bacteria.

Suggested Time 30-45 minutes

Objectives Students will learn to prepare a heat fix slide with a stain to they can observe cell structure in animals.

Materials (per lab group)

- microscope
- slides
- cover slips
- eyedropper
- toothpicks or tweezers
- candle and matches (with adult help)
- stain (you can use regular iodine or Lugol's Stain)
- sugar
- yeast
- container to mix your specimen in

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

Heat fixes are used when the specimens move all over the place when stained, like yeast. By drying out the specimen and fixing it to the slide, you can easily stain it several times to bring out the contrast and view the structure. This is a very good technique for viewing bacteria.

When you want to keep your specimens for a longer time, like a couple of months, simply apply a drop of superglue to the top of the slide before adding the coverslip. Press gently with a toothpick (not your fingers!) to squish out any bubbles.

Lesson

1. Ask: "*If I put something on the table and it is too wet and slippery, what can I do to make it less slippery?"*
2. Say: *"That's right! I can dry it off."*
3. Explain: *"One way we can dry things off is with heat. If I have a specimen a slide, and it is wiggling around too much, I can heat the slide to evaporate the water, so my specimen doesn't move around so much."*
4. Model: *"We don't need much heat, so we use a candle. Light it, then wave the slide quickly back and forth, so you don't burn the specimen or the slide."*
5. Have at least one student prepare a heat fix.
6. Explain: *"This is called a heat fix. We use it when what we want to look at is moving around too much. Specimens such as animal cells (like cheek cells) usually work best with a heat fix."*

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 your container with warm water. Add about a tablespoon of yeast (one packet is enough) along with a teaspoon of sugar. The warm water activates the yeast and the sugar feeds it. You should see a foam top form in about 10 minutes.
4. Using your eyedropper, grab a bit of your sample (you want the liquid, not the foam) and place a drop on a fresh slide. Spread the drop out with a toothpick. You want to smear it into a thin layer.
5. Light the candle (with adult help). Heat the slide in the flame by gently waving it back and forth. Don't stop it in the flame, or you'll get black soot on the underside of the slide and possibly crack it because the glass heats up and expands too fast. You also don't want to cook the yeast, as it will destroy what you want to look at. Just wave it around to evaporate the water.
6. Add a drop of iodine (or stain) to the slide. Wait 15 seconds.
7. Rinse it under water. (You can optionally stain it again if you find it's particularly difficult to see your specimen, but make sure to look at it first before repeat staining.)
8. Place a drop of water (use a clean eyedropper) on the specimen and add the cover slip.
9. Lower the stage to the lowest setting and rotate the nose piece to the lowest magnification power.
10. Place the slide on the stage in your clips.
11. Focus by looking through the eyepiece and slowly turning the coarse adjustment knob. When you're close to focus, switch to the fine adjustment knob until it pops into sharp view.
12. Adjust the light level to get the greatest contrast so you can see better.
13. Move the slide around (this is where a mechanical stage is wonderful to have) until you spot something interesting. Place it in the center of your field of view, and switch magnification power to find a great view (not too close, not too far away). Adjust your focus as needed.
14. Sketch what you see (don't forget the title and magnification power!)
15. NOTE: What other things can you look at? You can scrape the inside of your cheek with a toothpick and smear it on a fresh slide, take a mold sample from last week's leftovers in the fridge, or…? Have fun!

Exercises

1. Why do we use heat fixes? (To observe specimens that wiggle and squirm.)

2. Briefly describe how to do a heat fix. (Put a drop of the specimen on a slide and spread it thin with a toothpick. Light a candle and wave it back and forth underneath the slide, to evaporate the water. Add a drop of iodine, wait 15 seconds, then rinse. Place a drop of water on it, then place the cover slip on it.)
3. What is a specimen that needs a heat fix? (Animal cells.)

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: Heat Fixes

Student Worksheet

Name____

Overview If you tried looking at animal cells already, you know that they wiggle and squirm all over the place. And if you tried looking when using the staining technique, you know it only makes things *worse.* The heat fix technique is the one you want to use to nail your specimen to the slide and also stain it to bring out the cell structure and nuclei. This is the way scientists can look at things like bacteria.

What to Learn Heat fixes are used when the specimens move all over the place when stained, like yeast. By drying out the specimen and fixing it to the slide, you can easily stain it several times to bring out the contrast and view the structure.

Materials

- microscope
- slides
- cover slips
- eyedropper
- toothpicks or tweezers
- candle and matches (with adult help)
- stain (you can use regular iodine or Lugol's Stain)
- sugar
- yeast
- container to mix your specimen in

Lab Time

1. Fill your container with warm water. Add about a tablespoon of yeast (one packet is enough) along with a teaspoon of sugar. The warm water activates the yeast and the sugar feeds it. You should see a foam top form in about 10 minutes.
2. Using your eyedropper, grab a bit of your sample (you want the liquid, not the foam) and place a drop on a fresh slide. Spread the drop out with a toothpick. You want to smear it into a thin layer.
3. Light the candle (with adult help). Heat the slide in the flame by gently waving it back and forth. Don't stop it in the flame, or you'll get black soot on the underside of the slide and possibly crack it because the glass heats up and expands too fast. You also don't want to cook the yeast, as it will destroy what you want to look at. Just wave it around to evaporate the water.
4. Add a drop of iodine (or stain) to the slide. Wait 15 seconds.
5. Rinse it under water. (You can optionally stain it again if you find it's particularly difficult to see your specimen, but make sure to look at it first before repeat staining.)
6. Place a drop of water (use a clean eyedropper) on the specimen and add the cover slip.
7. Lower the stage to the lowest setting and rotate the nose piece to the lowest magnification power.
8. Place the slide on the stage in your clips.
9. Focus by looking through the eyepiece and slowly turning the coarse adjustment knob. When you're close to focus, switch to the fine adjustment knob until it pops into sharp view.

10. Adjust the light level to get the greatest contrast so you can see better.
11. Move the slide around (this is where a mechanical stage is wonderful to have) until you spot something interesting. Place it in the center of your field of view, and switch magnification power to find a great view (not too close, not too far away). Adjust your focus as needed.
12. Sketch what you see (don't forget the title and magnification power!) using the *Microscope Data Sheet.*
13. NOTE: What other things can you look at? You can scrape the inside of your cheek with a toothpick and smear it on a fresh slide, take a mold sample from last week's leftovers in the fridge, or…? Have fun!

Exercises Answer the questions below:

1. Why do we use heat fixes?

2. Briefly describe how to do a heat fix.

3. What is a specimen that needs a heat fix?

Heat Fix Microscope Data Table

Lesson #4: Plant Press

Teacher Section

Overview Art and science meet in a plant press. Whether you want to include the interesting flora you find in your scientific journal, or make a beautiful handmade greeting card, a plant press is invaluable. They are very cheap and easy to make, too!

Suggested Time 30-45 minutes

Objectives Different plants and animals inhabit different kinds of environments and have external features that help them thrive in different kinds of places. Plants and animals have structures that serve different functions in growth, survival, and reproduction.

Materials (per lab group)

- Newspaper
- Cardboard
- Belt buckle or large, strong rubber bands
- Sheets of paper

Lab Preparation

1. Helpful hints for the teacher:
    - It would be helpful, especially for younger students, for the teacher to precut the cardboard used for the plant press. 12in x 12in is a nice size for this plant press.
    - Tapping into school or home recycling bins can be an inexpensive, easy way to collect the newspaper and computer paper for the press.
    - Depending on how many students you have, you may only need one plant press, as each one can hold many plants.
    - Please note, however, that if you press odiferous plants (seaweed, corpse flower, etc), you may want a separate plant press for those.
2. Print out copies of the student worksheets.
3. Read over the Background Lesson Reading before teaching this class.
4. Watch the video for this experiment to prepare for teaching this class.
5. You can use plywood instead of cardboard with long bolts and wing-nuts instead of a cardboard and a belt buckle for making a demonstration version that will last you for years.

Background Lesson Reading

Plants have different parts that perform various functions for plant growth and survival. Many plants, though not all, have roots, stems, leaves and flowers. This lesson introduces students to these parts and their functions. The plant press lab can be made more interesting by using different plants. It can also be differentiated for more advanced studies by including plants from different groups (i.e. plants that do not have all of the parts we typically think of –roots, stems, leaves, flowers). See the background section for examples of plants. Additionally, this lesson can be enhanced by showing examples of plants with exaggerated parts, such as palm fronds to show extra large leaves or a beet to show an extra large root.

Plants are a crucial part of many environments, from deserts to rain forests, from oceans to plains. They provide animals with food, produce oxygen allowing animals to breathe, and provides shelter from weather or predators for animals. In short, without plants, animals would not be able to survive.

When we think about the parts of plants, we often thing about stems, leaves, seeds, or flowers. Many plants have these parts. However a plant does not need to have any of these parts to be considered a true plant. So, instead of talking about parts that all plants have, we'll talk about parts that some plants have.

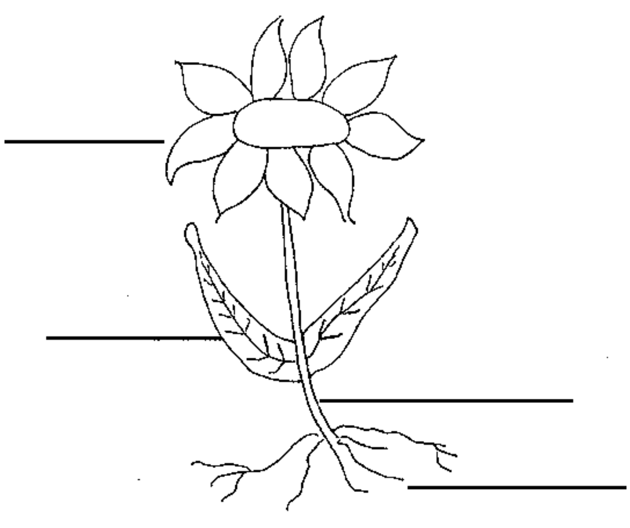
Some plants have tissue designed to move water, nutrients, and food to the places in the plants where it is needed. Plants with vascular tissue have two types of tissue. Xylem carries water and minerals. Water goes from the roots to all the other parts of the plants and also replaces the water that plants lose during photosynthesis. Phloem, the other type of vascular tissue, mainly carries sugars made during photosynthesis to the parts of the plants that need it.

Flowers and fruit generally have the function of attracting animals, which will assist the plant in reproducing, and get something for themselves in the process. When insects visit various flowers, getting sweet nectar, or when various animals eat fruit from a plant, getting nourishment, they help plants reproduce. We'll talk more about the specifics of plant reproduction a little bit later on.

Many people have admired the beautiful colors and smells of flowers, and this is no accident. The whole point of many flowers is to be attractive to animals, generally insects, to help in reproduction.

Lesson

1. Ask students what a (grown) plant looks like. Solicit verbal answers, so plant vocabulary emerges.
2. Draw a simple plant on the board. Make sure to include stems, roots, leaves, flowers.
   Here is a sample image:



3. Label the key parts with key vocabulary: roots, stem, leaves, flower.
4. Tell what each part does. Then write a vocabulary list off to the side of the drawing.
   Explain that the roots are the parts that grow underground, and they take in water and nutrients from the soil. The stem transports the water and nutrients up the plant, while the leaves are the site of transpiration and photosynthesis. The leaves allow some water to escape (transpiration), so that there is more room to take in more water and nutrients. Also, the leaves engage in photosynthesis, or the intake of sunlight for

energy, a process which releases oxygen. Finally, the flower's main function is to attract animals to assist in reproduction.

Vocabulary List:

- Root: takes in water and nutrients.
- Stem: transports water and nutrients.
- Leaf: allows for photosynthesis and transpiration. (takes in sunlight and lets out water!)
- Flower: attracts animals to help plants reproduce.

5. Explain that not all plants have all of these parts, but these are the basic parts of some plants.
6. Show students a plant and a pressed plant sample. Explain that they are going to press the plant flat by squeezing out the water. Demo the steps for lab below for students. (Or you may want to just show the video to save materials).

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 the cardboard into square pieces.
4. Cut or fold the sheets of newspaper into squares the same size as the cardboard.
5. Place 4 sheets of newspaper between each piece of cardboard. You can also use white copy paper.
6. Place the plants you want to press in between the newspaper.
7. If you want, you can sandwich the plant press with the wood planks for added pressure.
8. Bind it tightly with the rubber bands or a belt buckle.
9. Leave it in a dry place for two to four days.
10. Record data by drawing and labeling each part, and write what it does on the data sheet.

Exercises

1. Draw and describe the functions of the following plant parts: root, stem. (The root grows underground and draws water and nutrients into the plant. The stem carries those water and nutrients through the plant.)
2. What two major processes happen at the leaf? (Photosynthesis and transpiration).
3. Why are flowers necessary? (For reproduction. They attract animals that pollinate).
4. Do all plants have roots, stems, leaves and flowers? (No.)

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: Plant Press

Student Worksheet

Name____

Overview Plants have many parts that perform different functions. Not all plants have the same parts, but many plants have roots, stems, leaves and flowers. In today's lab, you will press a plant to be able to clearly see many of its parts.

What to Learn In this lab, you will press a plant as flat as possible. You will press the plant with extra force provided by cardboard and rubber bands to squeeze out as much water as possible. You will also press the plant between layers of paper to absorb the water. This will allow you to see the parts of the plant in the finished piece, without growing mold. Your finished pressed plant will be ready for any art project or simply framing by itself!

Materials

- Newspaper
- Cardboard
- Belt buckle or large, strong rubber bands
- Sheets of paper

Lab Time

1. Cut the cardboard into square pieces.
2. Cut or fold the sheets of newspaper into squares the same size as the cardboard.
3. Place 4 sheets of newspaper between each piece of cardboard. You can also use white copy paper.
4. Place the plants you want to press in between the newspaper.
5. If you want, you can sandwich the plant press with the wood planks for added pressure.
6. Bind it tightly with the rubber bands or a belt buckle.
7. Leave it in a dry place for two to four days.
8. Create a data table.

Plant Press Data Table

Plant Part (Draw and label)	Function?

Exercises Answer the questions below:

1. Draw and describe the functions of the following plant parts: root, stem.

2. What two major processes happen at the leaf?

3. Why are flowers necessary?

4. Do all plants have roots, stems, leaves and flowers?

Lesson #5: Celery Stalk Water Race

Teacher Section

Overview If you think of celery as being a bundle of thin straws, then it's easy to see how this experiment works. In this activity, you will get water to creep up through the plant tissue (the celery stalk) and find out how to make it go faster and slower. The part of the celery we eat is the stalk of the plant. Plant stalks are designed to carry water to the leaves, where they are needed for the plant to survive. The water travels up the celery as it would travel up any plant.

Suggested Time 30-45 minutes

Objectives : Students will demonstrate understanding of the process by which water travels through plants. Students know how to identify major structures of common plants and animals (e.g., stems, leaves, roots, arms, wings, legs). Roots are associated with the intake of water and soil nutrients and green leaves are associated with making food from sunlight. Light, gravity, touch, or environmental stress can affect the germination, growth, and development of plants. Plants and animals have structures that serve different functions in growth, survival, and reproduction. Students know how sugar, water, and minerals are transported in a vascular plant.

Materials (per lab group)

- Two clear containers (i.e. 12 oz glasses)
- 4+ stalks of celery, with leaves still attached (depending on how many variables they will test)
- Colored Water
- Paper towels
- Ruler
- Data recording sheet (worksheet and science journal)

Lab Preparation

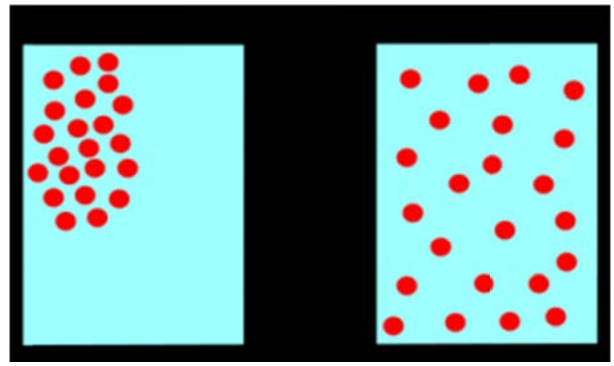
1. Teacher Prep before class starts:
   - Cut the ribs off of a stalk of celery. Keep the leaves on. You will need 4 ribs per group.
   - Wash the celery.
   - Prepare a 4 cup batch of colored water (color with food coloring).
2. Print out copies of the student worksheets.
3. Read over the Background Lesson Reading before teaching this class.
4. Watch the video for this experiment to prepare for teaching this class.

Background Lesson Reading

Cell membrane structure lets in the things the needed and didn't let in the things it didn't need, like a security guard deciding who should or shouldn't get into a building. There are two ways substances can get into a cell: Passive transport and Active Transport. In this experiment, we will focus on Passive Transport, specifically osmosis.

The first way substances can get into a cell is called **passive transport**. This process does not require any energy, because of the **concentration** of the substance inside and outside the cell. Concentration is how much of a substance there is in a certain area. In passive transport, the substance is going from an area of high concentration to low concentration.

To understand how this works, imagine blowing up a balloon and then letting the air out. When you do this, the air flows out quickly and without any extra energy because it is going from a place where there are a lot of air molecules (inside the balloon) to a place where there are fewer air molecules (outside the balloon.) In other words, it is going from an area of high concentration to low concentration.



The red dots are all in the top left corner. This is where the concentration is the biggest. The dots will move down and to the right, until they are spread out evenly.

Sometimes substances undergo passive transport all by themselves. They just slide right through the cell membrane. Other times they need a protein to help them make it across the membrane. But they *never* need energy, because they are going from high to low concentration. One special kind of passive transport is **osmosis,** when water crosses into the cell.

Lesson

1. Ask students the discussion question: *How do plants drink water?* Have them draw a quick illustration of their idea and share it with a partner.
2. Explain: Just like we have veins to carry our blood, celery has tubes (called xylem) to carry water. They are very narrow, so the water "automatically" travels up the narrow tube. It does so, because the water at the top of the tube "sweats away" (evaporates in a process called transpiration), so there is more room at the top of the tube. This is also known as the capillary effect.
   Illustrate and Relate: It is just like the air that automatically lets out of a balloon. (Blow up a balloon and then let the air out. Then, quickly show or draw illustration from above). The air travels from the most crowded area to the least crowded area. Water does the same thing in plants. Water travels from the space that is most crowded (the roots, the bottom of the tube) to the space that is least crowded, the top of the tube. Therefore, water travels up the celery stalk, defying gravity.
   CHECK UNDERSTANDING: Have students do a new quick draw of a plant drinking water, based on your explanation. Now draw and label the correct illustration on the board. Make sure all students have the correct illustration in their journals. Some students may have three illustrations total.
3. Demo the celery lab below for students. (Or you may want to just show the video to save materials). Then have students write a hypothesis as to what will happen to the celery stalk (i.e. what it will look like) by the end of the first time increment (start with an hour or two). Now students are ready to do the lab below.

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, find four celery stalks about the same size with leaves still attached.
4. Mix up a four-cup batch of colored water.

5. Place your celery stalks in the water, leaf-end up. After an hour or two, take it out and place it on the paper towel. Label your celery stalk with the each time length it was in the water.
6. Repeat this for different increments of time. Try one overnight!
7. Use a ruler and measure how high the water went. Record this in your science journal.
8. Now make a graph that compares the time to distance traveled by placing the time on the horizontal axis and the distance traveled on the vertical.
9. What happens if you start with hot water? Ice cold water? Salt water?
10. What happens if you cut the celery stalk at the base high enough so it straddles two cups of different colors?

Exercises

1. What two types of transport move substances into a cell? (Answer: Active and Passive.)
2. How does water get into the celery? (Answer: Osmosis.)
3. What are the tubes in celery called? (Answer: xylem.)
4. In what direction does air flow? Hint: Think of the balloon example. (Answer: Air flows from most concentrated area to least concentrated area).
5. What happens to the water after it travels through a plant? (Answer: It evaporates through transpiration).
6. Use answers 1-4 to describe the process of water traveling through a celery stalk. (Answer: Water enters a plant through a passive transport process called osmosis. It travels through the xylem, from most concentrated to least concentrated area. Thus, it travels from bottom to top. Once at the top, it evaporates, making room for new water flow.)

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: Celery Stalk Water Race

Student Worksheet

Name____

Overview You already know that plants need water to survive. But how do they actually drink that water? In this experiment, you will learn how water travels through a plant, and you will get to try to make the water go faster and slower!

What to Learn Carefully observe where the water is, when you cut the celery open. This will help you identify the structural element called the xylem. In this experiment, you will also measure how far the water travels in a certain amount of time, and you will get to change the water to try to make it go faster or slower.

Materials

- Two clear containers (i.e. 12 oz glasses)
- 4+ stalks of celery, with leaves still attached (depending on how many variables they will test)
- Colored Water
- Paper towels
- Ruler
- Data recording sheet (worksheet and science journal)

Lab Time

1. First, First, find four celery stalks about the same size with leaves still attached.
2. Mix up a four-cup batch of colored water.
3. Place your celery stalks in the water, leaf-end up. After an hour or two, take it out and place it on the paper towel. Label your celery stalk with the each time length it was in the water.
4. Repeat this for different increments of time. Try one overnight!
5. Use a ruler and measure how high the water went. Record this in your science journal.
6. Now make a graph that compares the time to distance traveled by placing the time on the horizontal axis and the distance traveled on the vertical.
7. What happens if you start with hot water? Ice cold water? Salt water?
8. What happens if you cut the celery stalk at the base high enough so it straddles two cups of different colors?

Celery Stalk Water Race Data Table

Time Celery Was in Water	Distance Water Traveled up Celery

Exercises Answer the questions below:

1. What two types of transport move substances into a cell?
2. How does water get into the celery?
3. What are the tubes in celery called?
4. In what direction does air flow? Hint: Think of the balloon example.
5. What happens to the water after it travels through a plant?
6. Use answers 1-4 to describe the process of water traveling through a celery stalk.

Lesson #6: Osmosis in Potatoes and Beans

Teacher Section

Overview One way substances can get into a cell is called passive transport. One special kind of passive transport is osmosis, when water crosses into the cell. This experiment allows you to see the process of osmosis in action. You should observe that the potato slice in the fresh water becomes a little stiffer, while the potato in salt water becomes rather flimsy.

Suggested Time 30-45 minutes

Objectives Cells function similarly in all living organisms. Students will observe osmosis of water moving from a low concentration of salt (water outside of a potato) to a high concentration of salt (inside of a salted potato). Students will observe osmosis of water as dry beans absorb water and expand overnight.

Materials (per lab group)

- 2 potato slices
- Dry beans (about a cup)
- 3 glasses of water
- salt
- a paper towel
- a cookie sheet

Lab Preparation

4. Pre -slice potatoes and give each group 2 slices
5. Print out copies of the student worksheets.
6. Read over the Background Lesson Reading before teaching this class.
7. Watch the video for this experiment to prepare for teaching this class.

Background Lesson Reading

There are two ways substances can get into a cell. The first way substances can get into a cell is called **passive transport**. This process does not require any energy, because of the **concentration** of the substance inside and outside the cell. Concentration is how much of a substance there is in a certain area. In passive transport, the substance is going from an area of high concentration to low concentration. This lab focuses on osmosis, a form of passive transport.

Cells are made of cells, and the water in the cells flows from areas of low salt concentration to high salt concentration. That means that if the water outside the cell is saltier than the water inside, water will move from the inside of the cell to the outside, just like the balloon example. As more and more of the cells lost water, the slice of potato became soft and flexible. If the water inside was saltier, the opposite happens, and some water goes into the cells, stiffening them up.

The beans absorbed the water through osmosis. The water moves from an area of high water concentration (outside of the bean) to an area of low water concentration (inside of the bean), rehydrating the beans and making them expand.

Lesson

1. Substances can move into cells by crossing into them. This is called osmosis.
2. Explain: *The flow of a substance from high to low concentration happens during passive transport. One kind of passive transport is called osmosis. During osmosis, water crosses into a cell.*
3. Explain: *Water moves from areas of low salt concentration to high salt concentration.*
4. Ask students to predict what will happen if they put a slice of potato in salt water. Which way will the water move?
5. Now start with the result. Ask students: *If we put a food item such as beans into a cup of water, and the water went into the beans, what does that mean in terms of concentration of water…where was it highest? lowest?*

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 two thin slices of potato. The pieces should be about the same thickness and be slightly flimsy.
4. Place both slices in separate glasses of water.
5. Add salt to one of the glasses.
6. Wait about 15 minutes.
7. Pull out the two pieces of potato and make observations in your science journal.

Let's do this experiment again, but use beans instead of potatoes:

8. Place enough beans and water in a glass to completely fill it.
9. Place the glass on a cookie sheet
10. Leave the glass alone for several hours… even overnight!
11. While you wait, take out your science journal and write about what you expect to happen. When your experiment is ready, record what you found.

Exercises

For Potatoes

1. How was the concentration of salt different in each cup? (The salt water had a higher concentration of salt than the fresh water.)
2. Which direction was water flowing in each cup? (In the salt water, from the potato to the water; in the fresh water, from the water to the potato.)
3. Why did one potato become stiff, while the other became flimsy? (The water moved from areas of low salt concentration to high. Therefore, it moved from the potato into the salt water, making the potato in the salt water flimsy. In the glass without salt water, water moved from low salt concentration (outside of the potato) to high salt concentration (inside the potato), making it firm.)

For Beans

4. The beans should begin to fall out of the water. If you look at them, you will see that they have expanded. What happened? (Water crossed into the bean cells through osmosis. It kept crossing until the beans were at a higher concentration of water than in the water. The beans expanded and fell out of the glass.)
5. Where was the concentration of water greater – inside or outside of the beans? Explain. (Concentration was greatest outside of the beans, because the water moves from areas of high to low concentration.)

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: Osmosis in Potatoes and Beans

Student Worksheet

Name____

Overview One way substances can get into a cell is called passive transport. One special kind of passive transport is osmosis, when water crosses into the cell. This experiment allows you to see the process of osmosis in action. You should observed that the potato slice in the fresh water became a little stiffer, while the potato in salt water became rather flimsy.

What to Learn Cells are made of cells, and the water in the cells flows from areas of low salt concentration to high salt concentration. That means that if the water outside the cell is saltier than the water inside, water will move from the inside of the cell to the outside. As the water left the cell it was like letting the air out of a balloon. As more and more of the cells lost water, the slice of potato became soft and flexible. If the water inside was saltier, the opposite happens, and some water goes into the cells, stiffening them up.

Materials

- 2 potato slices
- Dry beans (about a cup)
- 3 glasses of water
- salt
- a paper towel
- a cookie sheet

Lab Time

1. Cut two thin slices of potato. The pieces should be about the same thickness and be slightly flimsy.
2. Place both slices in separate glasses of water.
3. Add salt to one of the glasses.
4. Wait about 15 minutes.
5. Pull out the two pieces of potato and make observations in your science journal.

Let's do this experiment again, but use beans instead of potatoes:

6. Place enough beans and water in a glass to completely fill it.
7. Place the glass on a cookie sheet
8. Leave the glass alone for several hours… even overnight!
9. While you wait, take out your science journal and write about what you expect to happen. When your experiment is ready, record what you found.
10. Create a Data Table.

Osmosis in Potatoes and Beans Data Table

Food Item	Describe Flow of Water

Exercises Answer the questions below:

For Potatoes

1. How was the concentration of salt different in each cup?

2. Which direction was water flowing in each cup?

3. Why did one potato become stiff, while the other became flimsy?

For Beans

4. The beans should begin to fall out of the water. If you look at them, you will see that they have expanded. What happened?

5. Where was the concentration of water greater – inside or outside of the beans? Explain.

Lesson #7: Cool Carrot Osmosis

Teacher Section

Overview Osmosis is how water moves through a membrane. We're going to do two experiments on a carrot: first we're going to figure out how to move water into the cells of a carrot. Second, we'll look at how to move water within the carrot and trace it. Last, we'll learn how to get water to move out of the carrot. And all this has to do with cells!

Suggested Time 30-45 minutes

Objectives : Cells function similarly in all living organisms. Many multicellular organisms have specialized structures to support the transport of materials. Students will observe osmosis of water into a carrot by watching the movement of water within the carrot and learn about diffusion of water out of a carrot.

Materials (per lab group)

- 3 carrots
- Food coloring
- 3 tablespoons of salt
- Three glasses
- String
- water

Lab Preparation

1. Pre-slice the carrots as shown in the video. Do this just before the students arrive.
2. Print out copies of the student worksheets.
3. Read over the Background Lesson Reading before teaching this class.
4. Watch the video for this experiment to prepare for teaching this class.

Background Lesson Reading

A carrot is made up of cells surrounded by cell membranes. The cell membrane's job is to keep the cell parts protected. Water can pass through the membrane, but most things can't.

The carrot itself is a type of root—it is responsible for conducting water from the soil to the plant. The carrot is made of cells. Cells are mostly water, but they are filled with other substances too (organelles, the nucleus, etc).

And water always moves through cell membranes towards higher chemical concentrations. For example, a carrot sitting in salt water causes the water to move *into* the salty water. The water moves because it's trying to equalize the amount of water on both the inside and outside of the membrane. The act of salt will draw water out of the carrot, and as more cells lose water, the carrot becomes soft and flexible instead of crunchy and stiff.

You can reverse this process by sticking the carrot into fresh water. The water in the cup can diffuse through the membrane and into the carrot's cells. If you tie a string around the carrot, you'll be able to see the effect more clearly!

During the first part of the experiment, when surrounded by pure water, the concentration of water outside the carrot cells is greater than the concentration inside. Osmosis makes water move from greater concentrations to lesser concentrations. This is why the carrot grows in size—it fills with water!

During the second part of the experiment, the salt-water carrot shrunk while the non-salt-water carrot bloated! This is because of osmosis. Carrots are made up of cells. Cells are full of water. When the concentration of water outside the cell is greater than the concentration of water inside the cell, the water flows into the cell. This is why the non-salt-water carrot bloated—the concentration was greater outside the cell than inside. The concentration of water was greater inside the salt-water carrot than outside (because there was so much salt!) so the water flowed out of the cell. This made the salt-water carrot shrink.

Lesson

1. Explain: Osmosis is the process of water moving "by itself." It moves across membranes.
2. Explain: Water moves from the area of greater concentration to the area of lesser concentration.
3. Ask: When I stick a carrot (which has cells which have water) in a glass of water, where do you think there is a greater concentration of water?
4. Say: That's right: Outside of the carrot (in the glass). So which way would you expect the water to move?
5. Say: That's right, into the carrot. So would you expect the carrot to grow or shring?
6. Say: That's right, it would grow. How could we tell if it grew (got fatter)? We could tie a string around it to see if the string gets tighter around it.
7. Say: If water went into the carrot, would the carrot then be more firm or would it become flimsy?
8. Say: That's right, it would be more firm.
9. Now think about salt water. Is there a higher concentration of water, or a lower concentration of water than fresh water?
10. Explain: There is a lower concentration of water. So if we put a carrot in salt water, there is a lower concentration of water outside of the carrot.
11. Ask: Which way would the water move, then? Into the carrot or out of the carrot?
12. Say: That's right—water would move out of the carrot, because it would move to the area of lesser concentration of water.
13. Ask: If water leaves a carrot, does the carrot grow or shrink? That's right, it shrinks. If we tied a string around it, what should happen to the string? That's right, it should be looser. Ask: Would the carrot be more firm or more flimsy? That's right, it would be more flimsy, because it has less water.
14. Explain, we are now going to do an experiment to show what happens when we put a carrot in salt water, and what happens when we put it in fresh water. We will also put a carrot in colored fresh water, to see the path the water takes up the carrot. All of this water movement is possible because of osmosis.

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.

Experiment #1: Salt water moving into the Carrot

3. Cut the tip off of a carrot (with adult supervision).
4. Place the carrot in a glass half full of water
5. Place the carrot somewhere where it can get some sunshine.

6. Observe the carrot over several days.
7. Re-do the four steps above in a new cup, and this time put several (10-12) drops of food coloring into the water.
8. With the help of an adult, cut the carrot in half length-wise.

Experiment #2: Water moving out of the carrot

9. Snap the carrot in half and tie a piece of string around each piece of carrot (make sure they're tied tightly).
10. Place each half in a glass half full of warm water.
11. In one of the glasses, dissolve the salt.
12. Leave overnight.
13. The next morning pull on the strings. What do you observe?

Exercises

1. What happens if you try different vegetables besides carrots?(In the case of celery, potatoes and beans, the water still travels into the vegetable, to the area of lower water concentration.)
2. How do you think this relates to people? Do we really need to drink 8 glasses of water a day? (When we drink water, it moves into the areas of low water concentration, hydrating cells).
3. What happens (on the osmosis scale) if humans don't drink water? (We will dehydrate and become thirsty. If we don't get enough water, we will die.)
4. What did you expect to happen to the string? What *really* happened to the string? (Answers will vary for expectation. The string really stayed the same, but the carrot shrunk or became bloated).
5. Which solution made the carrot rubbery? Why? (The salt water made the carrot rubbery, because the lower concentration of water in the salt water caused the water to move out of the carrot, making it more flimsy.)
6. Did you notice a change in the cell size, shape, or other feature when soaked in salt water? (answers vary)
7. Why did we bother tying a string? Would a rubber band have worked? (We tied a string to measure the change in size in the carrot. If it gets bigger, the string gets tighter, and if it shrinks, the string becomes loose. A rubber band would not have worked, because it would have expanded or shrunk with the carrot).
8. What would happen to a surfer who spent all day in the ocean without drinking water? (The water in his cells would move out to the ocean, where the concentration of water is lower. Eventually, the surfer would dehydrate).
9. What do you expect to happen to human blood cells if they were placed in a beaker of salt water? (I would expect the cells to shrink, because the water in them would travel to the lower concentration of water in the salt water.)

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 #7: Cool Carrot Osmosis

Student Worksheet

Name____

Overview Osmosis is how water moves through a membrane. We're going to do two experiments on a carrot: first we're going to figure out how to move water into the cells of a carrot. Second, we'll look at how to move water within the carrot and trace it. Last, we'll learn how to get water to move out of the carrot. And all this has to do with cells!

What to Learn Water always moves through cell membranes towards higher chemical concentrations. For example, a carrot sitting in salt water causes the water to move *into* the salty water. The water moves because it's trying to equalize the amount of water on both the inside and outside of the membrane. The act of salt will draw water out of the carrot, and as more cells lose water, the carrot becomes soft and flexible instead of crunchy and stiff. When surrounded by pure water, the concentration of water outside the carrot cells is greater than the concentration inside. Osmosis makes water move from greater concentrations to lesser concentrations.

Materials

- 3 carrots
- Food coloring
- 3 tablespoons of salt
- Three glasses
- String
- water

Lab Time

Experiment #1: Salt water moving into the Carrot

1. Cut the tip off of a carrot (with adult supervision).
2. Place the carrot in a glass half full of water
3. Place the carrot somewhere where it can get some sunshine.
4. Observe the carrot over several days.
5. Re-do the four steps above in a new cup, and this time put several (10-12) drops of food coloring into the water.
6. With the help of an adult, cut the carrot in half length-wise.

Experiment #2: Water moving out of the carrot

7. Snap the carrot in half and tie a piece of string around each piece of carrot (make sure they're tied tightly).
8. Place each half in a glass half full of warm water.
9. In one of the glasses, dissolve the salt.
10. Leave overnight.
11. The next morning pull on the strings. What do you observe?

Cool Carrot Osmosis Data Table

Food Item	**Type of Liquid** *(fresh water, salt water, fresh water with food coloring)*	**Results** *(change in size, movement of liquid, change in flexibility)*

Exercises Answer the questions below:

1. What happens if you try different vegetables besides carrots?

2. How do you think this relates to people? Do we really need to drink 8 glasses of water a day?

3. What happens (on the osmosis scale) if humans don't drink water?

4. What did you expect to happen to the string? What *really* happened to the string?

5. Which solution made the carrot rubbery? Why?

6. Did you notice a change in the cell size, shape, or other feature when soaked in salt water?

7. Why did we bother tying a string? Would a rubber band have worked?

8. What would happen to a surfer who spent all day in the ocean without drinking water?

9. What do you expect to happen to human blood cells if they were placed in a beaker of salt water?

Lesson #8: Membranes

Teacher Section

Overview Here's a fun experiment that shows you how much stuff can pass through a membrane. Scientists call it the *semi-permeability of membranes.* You will measure how much fresh water can permeate stalks of celery. You will measure how much salt water leaves the celery stalks.

Suggested Time 30-45 minutes

Objectives Many multicellular organisms have specialized structures to support the transport of materials. Students will measure the semi-permeability of membranes in celery.

Materials (per lab group)

- 2 pieces of celery stalk
- salt
- 2 glasses
- a sensitive scale to weigh the celery

Lab Preparation

1. Trim the celery to be the same weight before you start your experiment.
2. Print out copies of the student worksheets.
3. Read over the Background Lesson Reading before teaching this class.
4. Watch the video for this experiment to prepare for teaching this class.

Background Lesson Reading

There are actually many hints that tell us something is alive. One thing that is true about all living things is that they all have tiny structures called cells. **Cells** are the smallest objects that can do all the things needed for life.

One way substances can get into a cell is called passive transport. One special kind of passive transport is osmosis, when water crosses into the cell.

This experiment allows you to see the process of osmosis in action. You should observe that the celery in the fresh water becomes a little stiffer, while the celery in salt water becomes rather flimsy. Remember that cells are made of cells and that the water in the cells flows from areas of low salt concentration (high water concentration) to high salt concentration (low water concentration). That means that if the water outside the cell is saltier than the water inside, water will move from the inside of the cell to the outside. As the water leaves the cell it is like letting the air out of a balloon. As more and more of the cells lost water, the celery becomes soft and flexible. If the water inside is saltier, the opposite happens, and some water will go into the cells, stiffening them up.

Lesson

1. Show students a dry paper towel and a small cup of water.
2. Ask: *What will happen if I put the paper towel in the water?*
3. Say: *That's right. The towel will soak up some water. Will the towel weigh more or less after it soaks up water? Thumbs up if you think it will weigh more.*
4. Say: *It will weigh more. The same is true of vegetables when they soak up water. More precisely, fresh water enters the vegetable because there is less concentration of water in the vegetable, and the water moves from areas of most to least concentration*.
5. Ask: *If I have the same paper towel, how can I tell how much water it soaked up?*
6. Say: *I can weigh the towel before and after soaking it up. The difference between the two weights will tell me the amount of water that went into the towel.*
7. Explain: *This process of water crossing into cells is called osmosis. Water moves from areas of lower water concentration to areas of higher water concentration.*
8. Explain and check for understanding: *We are going to do an experiment to see osmosis at work in celery. Knowing what we now know about osmosis, what would you expect to happen if I put the celery in a cup of fresh water? Which way would the water move? How much water would move?*
9. Check for understanding: *Now let's apply the concept of osmosis to salt water. What if I told you that salt water has a lower concentration of water than fresh water. If I put a vegetable in salt water, would you expect the water to move into or out of the vegetable? How much water would you expect to move?*
10. *Now we are going to test these hypotheses in our 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. First, weigh the celery (both pieces) and record this in your journal.
4. Next, make your hypotonic solution (plain water). Fill a glass with water and stick your celery in for ten minutes.
5. Remove the piece of celery and pat dry. Weight it again and record your results. If you don't see a weight difference, dip it in again for ten more minutes. Pat dry and weigh again.
6. Now make your hypertonic solution (salt water). Add a small amount of salt to the water (keep adding until no more can be dissolved and a small amount remains on the bottom).
7. Weight the second celery stalk and record it in your journal. Add this new celery stalk to the water. Wait impatiently for ten minutes. Remove and record the weight. Did you notice a difference? (Note – if you left the first one in for 20 minutes, make sure to leave this one in for the same amount of time.)
8. What effect did the salt solution have on the celery? Did it change in appearance? Did it feel different? Record your results in your journal!

Exercises

1. In what direction does water move? (from highest to lowest concentration).
2. What is the process by which water crosses membranes by itself? (osmosis).
3. What are all living things made of? (cells, which are mostly water)
4. Did the celery in the fresh water weigh more or less? Why? (Less. Because there is a higher concentration of water outside of the celery, so the water moved from outside (higher concentration) to inside the celery (lower concentration of water). This makes the celery weigh more).

5. Did the celery in the salt water weigh more or less after a few minutes? Why? (It weighed more, because water moved from higher concentration in the celery to lower concentration of water, outside the celery. This made the celery weigh less)

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: Membranes

Student Worksheet

Name____

Overview Here's a fun experiment that shows you how much stuff can pass through a membrane. Scientist call it the *semi-permeability of membranes.*

What to Learn There are actually many hints that tell us something is alive. One thing that is true about all living things is that they all have tiny structures called cells. **Cells** are the smallest objects that can do all the things needed for life. One way substances can get into a cell is called passive transport. One special kind of passive transport is osmosis, when water crosses into the cell.

This experiment allows you to see the process of osmosis in action. You should observe that the celery in the fresh water becomes a little stiffer, while the celery in salt water becomes rather flimsy. Remember that cells are made of cells and that the water in the cells flows from areas of low salt concentration (high water concentration) to high salt concentration (low water concentration). That means that if the water outside the cell is saltier than the water inside, water will move from the inside of the cell to the outside. As the water leaves the cell it is like letting the air out of a balloon. As more and more of the cells lost water, the celery becomes soft and flexible. If the water inside is saltier, the opposite happens, and some water will go into the cells, stiffening them up.

Materials

- 2 pieces of celery stalk
- salt
- 2 glasses
- a sensitive scale to weigh the celery

Lab Time

1. First, weigh the celery (both pieces) and record this in your journal.
2. Next, make your hypotonic solution (plain water). Fill a glass with water and stick your celery in for ten minutes.
3. Remove the piece of celery and pat dry. Weight it again and record your results. If you don't see a weight difference, dip it in again for ten more minutes. Pat dry and weigh again.
4. Now make your hypertonic solution (salt water). Add a small amount of salt to the water (keep adding until no more can be dissolved and a small amount remains on the bottom).
5. Weight the second celery stalk and record it in your journal. Add this new celery stalk to the water. Wait impatiently for ten minutes. Remove and record the weight. Did you notice a difference? (Note – if you left the first one in for 20 minutes, make sure to leave this one in for the same amount of time.)
6. What effect did the salt solution have on the celery? Did it change in appearance? Did it feel different? Record your results in your journal!
7. Create a Data Table.

Membranes Data Table

Solution	Time in Solution	Weight Before	Weight After

Exercises Answer the questions below:

1. In what direction does water move?
2. What is the process by which water crosses membranes by itself?
3. What are all living things made of?
4. Did the celery in the fresh water weigh more or less? Why?
5. Did the celery in the salt water weigh more or less after a few minutes?

Lesson #9: Water Cycle Column

Teacher Section

Overview When birds and animals drink from lakes, rivers, and ponds, how pure it is? Are they really getting the water the need, or are they getting something else with the water?
This is a great experiment to see how water moves through natural systems. We'll explore how water and the atmosphere are both polluted and purified, and we'll investigate how plans and soil help with both of these.

Suggested Time 30-45 minutes

Objectives : Students will understand how water cycles through natural systems by observing specific ways in which water is polluted and purified.

Materials (per lab group)

- three 2-liter soda bottles, empty and clean
- razor with adult help
- scissors
- tape
- ruler
- 60 cm heavy cotton string
- soil
- water
- ice
- plants
- drill and drill bits
- fast-growing plant seeds (radish, grass, turnips, Chinese cabbage, moss, etc.)

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 takes advantage of capillary action by using a wick to move the water from the lower aquarium chamber into the upper soil chamber, where it will both evaporate and transpire (evaporate from the leaves of plants) and rise until it hits a cold front and condenses into rain, which falls into your collection bucket for further analysis.

Lesson

1. Ask: *What are some ways I can get water from a cup into my mouth?* Brainstorm answers on the board.
2. If students need a hint, tell them to think about tools they can use.
3. Say: *That's right! I can use a straw.*

4. Explain: *Today we are going to use a "straw" to get water into our water chamber. This "straw" is a string/wick.*
5. Explain: *Once water enters the column, it moves through the plant via the roots and stem, and then exits through the leaves. This is called transpiration.*
6. Explain: *After it transpires through the leaves, it rises in the air until it hits a cold front. Then it condenses back into water (rain). This is the water we will capture in the little cup in our column.*
7. Explain: *We can then analyze the water for nutrients and pollution. What do you think will be in the water we find in the column?*

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 the bottle #1 below the shoulder. (Start cut with a razor, and finish with scissors)
4. Put the top of bottle#1 inside the other part, and set aside.
5. Get bottles #2 and #3
6. Cut bottle #2 above the hip.
7. Cut bottle #3 above the hip.
8. Put the cap on bottle #3 and drill a hole in it (with adult help).
9. Put the cap on bottle #2.
10. Fold 1 ft of thin rope string in half and put it in bottle #3 cap. Put the folded side through the hole and leave about half of the length out.
11. Tie 10 in of rope string around neck of bottle #2.
12. Put water in the bottom chamber.
13. Use a piece of foil to wrap around cap of bottle #2 to form a small cup. remove foil.
14. Put soil and plants in chamber 2.
15. Put the small foil cup next to the plant.
16. Slide bottle#2 into Bottle #3, cap first, and put the wick on bottle#2 into the foil cup.

Special notes:

1. Make sure your wicks are thoroughly soaked before adding the soil and plants! You can either add ice cubes to the top chamber or fill it carefully with water and freeze the whole thing solid. If you're growing plants from seeds, leave the top chamber off until they have sprouted.
2. You can add a strip of pH paper both inside and outside your soil chamber to test the difference in pH as you introduce different conditions. You can check out the Chemical Matrix Experiment and the Acid-Base Experiment also!)
3. You can place a bit of moss in the collection bucket to indicate how pure the water is (don't drink it – that's never a good idea).

Exercises

1. Do you think salt travels with the water? (Yes!)
2. What if you add salt to the aquarium chamber? Will it rain salty water? (No, because only water evaporates, but when you initially add it, it does travel with the water.)
3. What happens if you light a match, blow it out, and then drop it in the soil chamber? (You've just made acid rain bu adding in smog particles such as CO, CO_2, and NO_x gases.)

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: Water Cycle Column

Student Worksheet

Name____

Overview When birds and animals drink from lakes, rivers, and ponds, how pure it is? Are they really getting the water the need, or are they getting something else with the water? This is a great experiment to see how water moves through natural systems. We'll explore how water and the atmosphere are both polluted and purified, and we'll investigate how plans and soil help with both of these.

What to Learn We'll be taking advantage of capillary action by using a wick to move the water from the lower aquarium chamber into the upper soil chamber, where it will both evaporate and transpire (evaporate from the leaves of plants) and rise until it hits a cold front and condenses into rain, which falls into your collection bucket for further analysis.

Materials

- three 2-liter soda bottles, empty and clean
- razor with adult help
- scissors
- tape
- ruler
- 60 cm heavy cotton string
- soil
- water
- ice
- plants
- drill and drill bits
- fast-growing plant seeds (radish, grass, turnips, Chinese cabbage, moss, etc.)

Lab Time

1. Cut the bottle #1 below the shoulder. (Start cut with a razor, and finish with scissors)
2. Put the top of bottle#1 inside the other part, and set aside.
3. Get bottles #2 and #3
4. Cut bottle #2 above the hip.
5. Cut bottle #3 above the hip.
6. Put the cap on bottle #3 and drill a hole in it (with adult help).
7. Put the cap on bottle #2.
8. Fold 1 ft of thin rope string in half and put it in bottle #3 cap. Put the folded side through the hole and leave about half of the length out.
9. Tie 10 in of rope string around neck of bottle #2.
10. Put water in the bottom chamber.
11. Use a piece of foil to wrap around cap of bottle #2 to form a small cup. remove foil.
12. Put soil and plants in chamber 2.
13. Put the small foil cup next to the plant.
14. Slide bottle#2 into Bottle #3, cap first, and put the wick on bottle#2 into the foil cup.

15. Draw a complete diagram of your water cycle column, explaining how each section works.
16. Create a Data Table where you track the effect of salt on the plants over a two week period.

Water Cycle Column Data Table

Date	**Amount of Salt Added to Water Supply**	**Effect on Plants**

Exercises Answer the questions below:

1. Do you think salt travels with the water?

2. What if you add salt to the aquarium chamber? Will it rain salty water?

3. What happens if you light a match, blow it out, and then drop it in the soil chamber? (Hint – you've just made acid rain!)

Lesson #10: Homemade Hydrometer

Teacher Section

Overview With a name like hydrometer you might pause and say: *"…a what?"* You might have even gone a step further and added *"why do I want one of those?"* Simply put, hydrometers test the density of liquids. Specifically, they compare the density of liquids to the density of water (a comparison called the specific gravity of a substance). A substances specific gravity is extremely useful. We use it to tell how creamy milk is, how salty the ocean is, and much more! In the following experiments we'll test the salinity of several solutions.

Suggested Time 30-45 minutes

Objectives : Students will understand that the density of a liquid determines how much force it exerts on objects floating in it.

Materials (per lab group)

- Drinking straw
- Modeling clay
- A drinking glass
- Salt
- Distilled water (or as filtered as you have on hand)
- Permanent marker
- Graph paper (optional)

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 hydrometer works via the *Archimedes Principle* which states that an object will be buoyed up by the force equal to the weight of the fluid displaced. Thus, the more dense the fluid, the more force it exerts on objects floating in it. This is why the hydrometer moves higher as more salt is added. Cool, huh?

Lesson

1. Ask a student to hold a heavy textbook in one hand, outstretched at waist level.
2. Ask another student to stand next to the first student, and help hold the same textbook with one hand outstretched.
3. Ask a third student, and see if they all can raise the textbook to shoulder or even head height.
4. Students should notice that the more hands there are, the more strength there is to hold the book, and it easier to raise up higher.
5. Explain: Liquid has this same strength, and it can get stronger as it gains density. For instance salt water and honey are denser than fresh water.

6. Explain: Because these liquids are more dense (stronger), they push harder on the objects in them. Therefore the objects raise up higher in the liquid.
7. Explain: Today we are going to build a tool that helps us measure just how strong the liquid is by measuring how much of a straw it can lift. We will add salt to the water, instead of more students underneath the book!

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. Plug one end of the straw with a small marble-size ball of clay. This is your hydrometer.
4. Fill your glass with water (find a glass that holds about 2 to 2.5 cups of water).
5. Place the hydrometer in the glass. Add or remove clay until the straw floats midway up your glass. Mark that level “0” with the permanent marker (because there is no salt).
6. Remove the hydrometer.
7. Add 1 teaspoon of salt to the water.
8. Place the hydrometer in the glass. Mark the new level and label it “10” for 10 ppt (parts per thousand).
9. Add another teaspoon of salt to the solution.
10. Repeat step 6 (except this time mark the level “20” for 20ppt).
11. Repeat until you have marks up to 50 (or higher!).
12. Have a partner prepare unknown solutions of salt and water. Test them with the hydrometer. Graph your findings.
13. Try solutions at different temperatures. (Water is most dense at 4^{o}C, which is the temperature at the bottom of most deep lakes and seas).
14. Troubleshooting***:*** Is your hydrometer not working correctly? First, check the plug. If the plug is letting water the hydrometer may be getting heavier as you add salt—the opposite result you expect!

Exercises

1. What do hydrometers test? (the density of liquids)
2. What is specific gravity? (the density of water)
3. What is the Archimedes Principle? (theory which states that an object is buoyed up by the force equal to the weight of the water displaced. The denser the liquid, the more pressure it exerts on an object and the more water is displaced.)
4. Would a boat float better in water or honey? Why? (It would float better in honey, because honey is a denser liquid, hence it exerts more force on the boat to buoy it up.)

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: Homemade Hydrometer

Student Worksheet

Name____

Overview With a name like hydrometer you might pause and say: *"...a what?"* You might have even gone a step further and added *"why do I want one of those?"* Simply put, hydrometers test the density of liquids. Specifically, they compare the density of liquids to the density of water (a comparison called the specific gravity of a substance). A substances specific gravity is extremely useful. We use it to tell how creamy milk is, how salty the ocean is, and much more! In the following experiments we'll test the salinity of several solutions.

What to Learn The hydrometer works via the *Archimedes Principle* which states that an object will be buoyed up by the force equal to the weight of the fluid displaced. Thus, the more dense the fluid, the more force it exerts on objects floating in it. This is why the hydrometer moves higher as more salt is added.

Materials

- Drinking straw
- Modeling clay
- A drinking glass
- Salt
- Distilled water (or as filtered as you have on hand)
- Permanent marker
- Graph paper (optional)

Lab Time

1. Plug one end of the straw with a small marble-size ball of clay. This is your hydrometer.
2. Fill your glass with water (find a glass that holds about 2 to 2.5 cups of water).
3. Place the hydrometer in the glass. Add or remove clay until the straw floats midway up your glass. Mark that level "0" with the permanent marker (because there is no salt).
4. Remove the hydrometer.
5. Add 1 teaspoon of salt to the water.
6. Place the hydrometer in the glass. Mark the new level and label it "10" for 10 ppt (parts per thousand).
7. Add another teaspoon of salt to the solution.
8. Repeat step 6 (except this time mark the level "20" for 20ppt).
9. Repeat until you have marks up to 50 (or higher!).
10. Have a partner prepare unknown solutions of salt and water. Test them with the hydrometer. Graph your findings.
11. Complete the data table below.

Homemade Hydrometer Data Table

Solution	Density

Exercises Answer the questions below:

1. What do hydrometers test?

2. What is specific gravity?

3. What is the Archimedes Principle?

4. Would a boat float better in water or honey? Why?

Lesson #11: Worms!

Teacher Section

Overview We're going to discuss the differences between three types of worms; flatworms, roundworms, and segmented worms. The word "worm" is not, in fact, a scientific name. It's an informal way of classifying animals with long bodies and no appendages (no including snakes). They are bilaterally symmetrical (the right and left sides mirror each other). Worms live in salt and fresh water, on land, and inside other organisms as parasites

Suggested Time 30-45 minutes

Objectives : Students will observe worms at work in soil to understand the benefits of worms to gardening. Students will learn the differences among three types of worms: flatworms, round worms, and segmented worms.

Materials (per lab group)

- two 2-liter soda bottles, empty and clean
- one brown paper grocery bag
- 20 red worms
- newspaper, old leaves, peat moss, and/or straw for worm bedding
- last night's dinner, organic scraps, plant material for worm food

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. Note: Red worms are good, but they are not the same as the ones in your garden. You may need to order them online.

Background Lesson Reading

The differences between the three types of worms we will discuss depend on the possession of a body cavity and segments. Flatworms have neither a body cavity nor segments. Roundworms only have a body cavity, and segmented worms have both a body cavity and segments.

Flatworms (Phylum Platyhelminthes) have incomplete digestive systems. That means that their digestive system has only one opening. The gas exchange occurs on the surface of their bodies. There are no blood vessels or nervous systems in flatworms. Some are non-parasitic, like the Sea flat worm, and some are parasitic, like the tapeworm.

Roundworms (Phylum Nematoda) have body cavities—as contrasted with flatworms which do not. The body cavity allows roundworms to have complete digestive tracts (both a mouth and an anus). The mouth and anus are connected by a gut—where the food is digested. They also have a simple nervous system and brain. Roundworms can be parasites of plants and animals. In dogs they are often know to cause heart problems. In humans roundworm parasites can sometimes cause a swelling disease called elephantitis.

Annelids or Segmented Worms (Phylum Annalida) the most developed of the three, have both a body cavity and segments. Their body cavity helps give them structure—it serves as a hydroskeleton. By "segmented" it's meant that they are divided into repeating units. They can be non-parasitic (i.e. earthworms) or parasitic (i.e. leeches). Interestingly, the giant red leech only eats giant earthworms.

Lesson

1. Ask students if they often see worms. If so where and what do they look like? They should quickly share this with a partner.
2. Ask a student to draw three worms on the board: a flatworm, a round worm and a segmented worm.
3. Explain: *Even though worms have simple structures, some worms have more sophisticated structures than others. The flatworm is the simplest of them all, with no body cavity and no segments. It also does not have a complete digestive system. It has one opening, and then gas exchanges happen through the surface of their bodies.*
4. Explain: *Round worms are the next type of worm. They have a body cavity and a complete digestive system, i.e. a mouth and an anus. These are connected by a gut, so food goes in, gets digested and waste is excreted.*
5. Explain: *A segmented worm is the most complex type. It has a body cavity, which gives it structure, along with repeating segments.*
6. Draw a sketch of each worm on the board from the Background Reading section.

Benefits of worms:

7. Ask students what we need to do to a garden once its planted to help it grow.
8. Write answers on the board. Add the following if they do not come up with them: churn the soil, fertilize or feed the soil, have a strong, secure root system to soak up nutrients and water from the soil.
9. Ask: *What would you do if you saw a worm in the garden? I would leave it, because it does much of the gardening work for us.*
10. Explain: *Worms breakdown plant matter and turn it into fertilizer for the soil. Additionally, they churn the soil as they move, and finally, they create tunnels so that root systems can more easily grow into the dirt.*
11. Now ask again: *What would you do if you saw a worm in the garden?* Hopefully students will say they would leave it!

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.

How to make the worm column:

3. Cut the top off of bottle#1 above the shoulder
4. Poke 8 holes in a ring around the top of bottle#1
5. Poke 8 holes in a ring around the middle of bottle#1
6. Poke 8 holes in a ring around the hip of bottle#1
7. Poke a hole in each of the feet of bottle#1
8. Cut bottle #2 in half
9. Place bottle #1 inside of the bottom of bottle#2

10. Put the top of bottle#2 on the top of bottle#1
11. Measure the paper that you will use to darken your worm farm(roll the whole column in a paper bag and then tape it. Cut the paper column that you now have so that you can see the top of the worm column. Tape the paper column with one piece of tape on top, if you hang the worm column)
12. Put strips of ripped newspaper in bottle #1. You may want to dip them in water first.
13. Put soil in with the newspaper and mix it up a little.
14. Fill bottle #1 about 2/3 with the newspaper and soil mixture.
15. You may add crushed egg shells to the paper/soil mixture as well.
16. Put the column back together.
17. Feed food scraps every 3-4 days.

Exercises

1. What are three types of worms? (flat, round, segmented)
2. What are the characteristics of each? (flat worms have an incomplete digestive system and no body cavity; round worms have a body cavity and a complete digestive system; and segmented worms have a body cavity and repeating segments)
3. What are the elements of a complete digestive system? (a mouth, an anus, connected by a gut).
4. What are some benefits of worms in gardening? (They churn the soil; they decompose plant matter into fertilizer; they dig tunnels allow roots to plant themselves more easily.)

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: Worms!

Student Worksheet

Name____

Overview Here we're going to discuss the differences between three types of worms; flatworms, roundworms, and segmented worms. The word "worm" is not, in fact, a scientific name. It's an informal way of classifying animals with long bodies and no appendages (no including snakes). They are bilaterally symmetrical (the right and left sides mirror each other). Worms live in salt and fresh water, on land, and inside other organisms as parasites.

If you're fascinated by worms but frustrated that you can't see them do their work underground, then this worm column is just the ticket for you. By using scrap materials from the recycling bin, you'll be able to create a transparent worm farm.

What to Learn The differences between the three types of worms we will discuss depend on the possession of a body cavity and segments. Flatworms have neither a body cavity nor segments. Roundworms only have a body cavity, and segmented worms have both a body cavity and segments.

Materials

- two 2-liter soda bottles, empty and clean
- one brown paper grocery bag
- 20 red worms
- newspaper, old leaves, peat moss, and/or straw for worm bedding
- last night's dinner, organic scraps, plant material for worm food

Lab Time

How to make the worm column:

1. Cut the top off of bottle#1 above the shoulder
2. Poke 8 holes in a ring around the top of bottle#1
3. Poke 8 holes in a ring around the middle of bottle#1
4. Poke 8 holes in a ring around the hip of bottle#1
5. Poke a hole in each of the feet of bottle#1
6. Cut bottle #2 in half
7. Place bottle #1 inside of the bottom of bottle#2
8. Put the top of bottle#2 on the top of bottle#1
9. Measure the paper that you will use to darken your worm farm(roll the whole column in a paper bag and then tape it. Cut the paper column that you now have so that you can see the top of the worm column. Tape the paper column with one piece of tape on top, if you hang the worm column)
10. Put strips of ripped newspaper in bottle #1. You may want to dip them in water first.
11. Put soil in with the newspaper and mix it up a little.
12. Fill bottle #1 about 2/3 with the newspaper and soil mixture.
13. You may add crushed egg shells to the paper/soil mixture as well.
14. Put the column back together.

15. Feed food scraps every 3-4 days.
16. Create a Data Table.

Worm Column Data Table

Attribute	Description
Length?	
Outer layer—hard?segmented?	
Legs?	
Antennae?	
Main similarities?	
Main differences?	

Exercises Answer the questions below:

1. What are three types of worms?

2. What are the characteristics of each?

3. What are the elements of a complete digestive system?

4. What are some benefits of worms in gardening?

Lesson #12: Eco Column

Teacher Section

Overview What grows in the corner of your windowsill? In the cracks in the sidewalk? Under the front steps? In the gutter at the bottom of the driveway? Specifically, *how* do these animals build their homes and how much space do they need? What do they eat? Where do fish get their food? How do ants find their next meal?

These are hard questions to answer if you don't have a chance to observe these animals up-close. By building an eco-system, you'll get to observe and investigate the habits and behaviors of your favorite animals. This column will have an aquarium section, a decomposition chamber with fruit flies or worms, and a predator chamber, with water that flows through all sections. This is a great way to see how the water cycle, insects, plants, soil, and marine animals all work together and interact.

Suggested Time 30-45 minutes

Objectives Students will observe and identify the behaviors of various plants and animals in various components of an ecosystem: the aquarium, the decomposition unit, the plant/animal chamber, and the precipitation funnel. Students will also identify the role of different plants and animals in their eco column: producers, consumers, and decomposers. Specifically, students will learn: animals eat plants or other animals for food and may also use plants or even other animals for shelter and nesting; producers and consumers (herbivores, carnivores, omnivores, and decomposers) are related in food chains and food webs, and may compete with each other for resources in an ecosystem; and over time, matter is transferred from one organism to others in the food web, and between organisms and the physical environment.

Materials (per lab group)

- four (or more) 2-liter soda bottles, empty and clean and with caps
- scissors
- tape
- razor with adult help
- ruler
- soil
- water
- plants or seeds
- compost or organic/food scraps
- spiders, snails, fruit flies, etc

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. You may want to pre-slice into the bottles to provide a starting point for students to cut with scissors.

Background Lesson Reading

Animals are all around us. As we walk through our neighborhood, we likely see animals being kept as pets, insects crawling on the ground, and birds flying through the trees. Depending on where you live, you may also see animals living in rivers, lakes, and swamps. How are these animals similar? How are they different? Why do they behave in the ways they do? How do their actions affect the environment in which they live? These are big questions that we'll be answering.

Organisms exist in relationship to one another. It is difficult to know how they exist—how they find shelter, what they eat, how long they live—until you observe them. In this lab, you'll get to observe and investigate the habits and behaviors of your favorite animals by building an Eco Column. This column will have an aquarium section, a decomposition chamber with fruit flies or worms, and a predator chamber, with water that flows through all sections. This is a great way to see how the water cycle, insects, plants, soil, and marine animals all work together and interact.

Lesson

1. Ask students to explain a simple food web. You may start them off by drawing a picture of a bird and asking, "*What does a bird eat?*" When they answer "*fish*," you can draw the fish on the board with an arrow going from the bird to the fish. Let students give ideas for about a minute. Record their answers to form a simple web on the board. If they run out of answers, you can start a new simple web by saying, "*Humans eat beef. What do cows eat*?" This can be a simple way to introduce plants into the food web, especially for younger students.
2. Explain: *Mapping out who eats what is called a food web. Today we are going to study the parts of a food web and then build our own column that helps us observe a food web in process. We will see exactly how organisms live—how they build shelter, how they eat, and what they eat.*
3. Explain: *A food web shows the transfer of energy from one organism to another. We eat because we need energy, and food gives us that energy.*
4. Explain: *Today we are going to build an Eco Column, which will allow us to see organisms eating other organisms, or transferring energy. In our Eco Column, we will have: water, plants, fruit, fruit flies, and bugs*. List these words on the board.
5. Ask students to tell how they think the bug lives in this environment (what it eats, how it finds shelter, how it rests, how it behaves). Explain that we are going to observe the bug's life (along with other organisms) in this activity.
6. Explain the set up of the Eco Column. The aquarium is in the bottom, then the decomposition unit (plant matter, small amounts of fruit and fruit flies), then the egotron (bugs), then the precipitation funnel (water).
7. Show the video for constructing it.

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 bottle #1 2 cm below the shoulder. Start the cut with a razor, and finish it with scissors.
4. Drill a hole in the cap and poke holes in the side of the bottle for drainage for soil.
5. Cut bottle #2 1 cm below the hip.

6. Carefully measure 1 cm below the shoulder of bottle #2 and cut all the way around. The lip of this cut should be straight.
7. On bottle #3, measure 1 cm below the shoulder and cut all the way around.
8. Cut 2cm below the hip of bottle #3. You want this end tapered.
9. Put a cap on bottle #3.
10. Shove through the tapered bottom, so it sits an inch up from the bottom.
11. Cut bottle #4 1 cm above the hip.
12. Put the whole column together: Put bottle #1 top into bottle #2 middle, slide the above section into bottle #3, insert the last bottle cut upside down, and put the remaining bottle bottom on the whole apparatus.
13. Once the whole Eco Column is together, number each section so you can quickly and easily reassemble it, once you fill each section.
14. Take the sections apart and fill them as follows: bottom section is aquarium so fill with water. The next is the decomposition unit—put in plant matter, small amounts of fruit for the fruit fly breeding ground. Then is the plant/animal chamber—fruit flies. You can cut a port hole that tapes shut in the side of this section, for easier access. Finally is the precipitation funnel—allow water to drip down the column

Exercises

1. What are parts of the eco system? (Water, producers, decomposers, consumers)
2. Give an example of each? (Water-precipitation from rain water; producers-fruit; decomposers-fruit flies; predators- insects).
3. What do decomposers do? (Decomposers eat plant matter and turn it into waste, thereby decomposing the plant).
4. How do fruit flies breed? (Fruit flies feed on ripe fruit. They lay their eggs in the skin of fruit. They have a very quick life cycle— about 8 days).
5. How does the precipitation funnel function in this eco column? (Water drips in from the top, providing water for the eco column).

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: Eco Column

Student Worksheet

Name____

Overview Organisms exist in relationship to one another. It is difficult to know how they exist—how they find shelter, what they eat, how long they live—until you observe them. In this lab, you'll get to observe and investigate the habits and behaviors of your favorite animals by building an Eco Column. This column will have an aquarium section, a decomposition chamber with fruit flies or worms, and a predator chamber, with water that flows through all sections. This is a great way to see how the water cycle, insects, plants, soil, and marine animals all work together and interact.

What to Learn Organisms exist in relationship to one another. It is difficult to know how they exist—how they find shelter, what they eat, how long they live—until you observe them. In this lab, you'll get to observe and investigate the habits and behaviors of your favorite animals by building an Eco Column. This column will have an aquarium section, a decomposition chamber with fruit flies or worms, and a predator chamber, with water that flows through all sections. This is a great way to see how the water cycle, insects, plants, soil, and marine animals all work together and interact.

Materials

- four (or more) 2-liter soda bottles, empty and clean and with caps
- scissors
- tape
- razor with adult help
- ruler
- soil
- water
- plants or seeds
- compost or organic/food scraps
- spiders, snails, fruit flies, etc

Lab Time

1. Cut bottle #1 2 cm below the shoulder. Start the cut with a razor, and finish it with scissors.
2. Drill a hole in the cap and poke holes in the side of the bottle for drainage for soil.
3. Cut bottle #2 1 cm below the hip.
4. Carefully measure 1 cm below the shoulder of bottle #2 and cut all the way around. The lip of this cut should be straight.
5. On bottle #3, measure 1 cm below the shoulder and cut all the way around.
6. Cut 2cm below the hip of bottle #3. You want this end tapered.
7. Put a cap on bottle #3.
8. Shove through the tapered bottom, so it sits an inch up from the bottom.
9. Cut bottle #4 1 cm above the hip.

10. Put the whole column together: Put bottle #1 top into bottle #2 middle, slide the above section into bottle #3, insert the last bottle cut upside down, and put the remaining bottle bottom on the whole apparatus.
11. Once the whole Eco Column is together, number each section so you can quickly and easily reassemble it, once you fill each section.
12. Take the sections apart and fill them as follows: bottom section is aquarium so fill with water. The next is the decomposition unit—put in plant matter, small amounts of fruit for the fruit fly breeding ground. Then is the plant/animal chamber—fruit flies. You can cut a port hole that tapes shut in the side of this section, for easier access. Finally is the precipitation funnel—allow water to drip down the column
13. Create a data table.

Eco Column Data Table

Date	Organism	Behavior

Exercises Answer the questions below:

1. What are parts of the eco system?
2. Give an example of each.
3. What do decomposers do?
4. How do fruit flies breed?
5. How does the precipitation funnel function in this eco column?

Lesson #13: Carnivorous Greenhouse

Teacher Section

Overview Carnivorous plants are heterotrophs. This means they must get their energy from other organisms instead of the sun. Such plants are good at catching small animals, such as insects, to eat. In this activity, you'll make a greenhouse with carnivorous plants so you can track their growth and behavior.

Suggested Time 30-45 minutes

Objectives : Students will learn the components of a greenhouse with carnivorous plants. Students will also understand how to grow carnivorous plants. Animals eat plants or other animals for food and may also use plants or even other animals for shelter and nesting. Producers and consumers (herbivores, carnivores, omnivores, and decomposers) are related in food chains and food webs, and may compete with each other for resources in an ecosystem. The number and types of organisms an ecosystem can support depends on the resources available and abiotic factors, such as quantity of light and water, range of temperatures, and soil composition.

Materials (per lab group)

- clear plastic tub with lid
- sand (regular sandbox sand)
- peat moss
- rubber glove
- water, mineral free (distilled or reverse osmosis)
- spray bottle with mineral free water in it

Lab Preparation

1. Helpful hints for the teacher:
   - Teacher will need to order carnivorous plants ahead of time.
   - Rinse sand, if it is from the beach or has minerals in it.
2. Print out copies of the student worksheets.
3. Read over the Background Lesson Reading before teaching this class.
4. Watch the video for this experiment to prepare for teaching this class.

Background Lesson Reading

Carnivorous plants are native to humid regions with poor soil, therefore they have learned to get their nutrients elsewhere, such as from insects. Carnivorous greenhouses or terrariums also need lots of water and light. Cover the terrarium to create humidity, but they also need air flow, so only cover about ½ way with the lid. If you use artificial light, time it for 12-14 hours per day, because carnivorous plants do need to rest. Some carnivorous plants such as Venus Fly Traps or Pitcher Plants also need to go dormant, so keep them below 40 degrees for 3 months. You can do so by putting them in the refrigerator. Most carnivorous plants only eat about 1-2 insects per month, so don't overfeed them.

4 Things To Remember about Carnivorous Gardens:

- Keep the plant wet at all times
- The water must be as clean as possible. It must be mineral free water, such as distilled or ro.
- The soil must also be as clean as possible. It must be mineral free, so rinse sand, if it is from the beach.
- The terrarium needs lots of sunlight. A window sill is a perfect place to put it.

Lesson

1. Show students a carnivorous plant and an insect. Ask them: *"What is the relationship between these two organisms?"*
2. Explain: *The plant is a carnivorous plant, also known as a heterotroph. It grows in humid regions with poor soil quality, so it needs similar conditions to survive. It is called a carnivorous plant, because it has learned to get its energy from insects. It captures and digests insects.*
3. Show pictures of different carnivorous plants, such as a Venus fly trap and a pitcher plant.
4. Explain that in this activity, students are going to build a greenhouse for these plants.

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 on rubber gloves.
4. Put a layer of regular play box sand in the clear container.
5. Next, put a layer of peat moss in the container equal to the amount of sand you just put in.
6. Mix the two layers together using hands.
7. Wet the mix with about 16 oz of mineral free water.
8. Plant your carnivorous plant(s) in the container.

Exercises

1. What is a carnivorous plant? (a plant that gets its energy from insects)
2. What is another name for a carnivorous plant? (heterotroph)
3. What does a carnivorous plant need to thrive? (light, humidity, air flow, insects and water and soil with minimal nutrients)
4. Should we fertilize a carnivorous plant? Why or why not? (no, because that will burn the roots)

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: Carnivorous Greenhouse

Student Worksheet

Name____

Overview Have you ever seen a man-eating plant? Well, maybe not, but you may have seen a Venus Fly Trap. Such a plant is called a carnivorous plant, since it eats insects for energy. In this activity, you'll make a greenhouse with carnivorous plants so you can observe and track their growth and behavior, including their eating habits.

What to Learn Carnivorous plants are heterotrophs. This means they must get their energy from other organisms instead of the sun. They are native to regions with poor soil, so they have learned to get their energy from insects. Such plants are good at catching small animals, such as insects, to eat.

Carnivorous plants also need much water and light, as well as some humidity and air flow. If you cover the terrarium, make sure you leave the lid partially open for air flow. Also, it is very important not to fertilize heterotrophs. In other words, use water and soil with no minerals or nutrients.

Materials

- clear plastic tub with lid
- sand (regular sandbox sand)
- peat moss
- rubber glove
- water, mineral free (distilled or reverse osmosis)
- spray bottle with mineral free water in it

Lab Time

1. Put on rubber gloves.
2. Put a layer of regular play box sand in the clear container.
3. Next, put a layer of peat moss in the container equal to the amount of sand you just put in.
4. Mix the two layers together using hands.
5. Wet the mix with about 16 oz of mineral free water.
6. Plant your carnivorous plant(s) in the container.

Carnivorous Greenhouse Data Table

Date	Plant Type	Growth	Eating Habits

Exercises Answer the questions below:

1. What is a carnivorous plant?

2. What does a carnivorous plant need to thrive?

3. Should we fertilize a carnivorous plant? Why or why not?

Lesson #14: Carbon Dioxide and Photosynthesis

Teacher Section

Overview Photosynthesis is a process where light energy is changed into chemical energy. This process happens in the chloroplast of plant cells. Photosynthesis is one of the most important things that happen in cells. In fact, photosynthesis is considered one of the most important processes for all life on Earth. It makes sense that photosynthesis is really important to plants, since it gives them energy, but why is it so important to animals? In this lab, you will see evidence of plants giving off the oxygen animals need to survive.

Suggested Time 30-45 minutes

Objectives : Plants use carbon dioxide (CO2) and energy from sunlight to build molecules of sugar and release oxygen. Energy entering ecosystems as sunlight is transferred by producers into chemical energy through photosynthesis, and then from organism to organism in food webs. Mitochondria liberate energy for the work that cells do, and chloroplasts capture sunlight energy for photosynthesis. Students will observe evidence of plants giving off oxygen in the process of photosynthesis.

Materials (per lab group)

- candle
- lighter with adult help
- large glass jar
- stopwatch
- leafy plant (weeds work also)
- Optional: sodium hydroxide and iodine

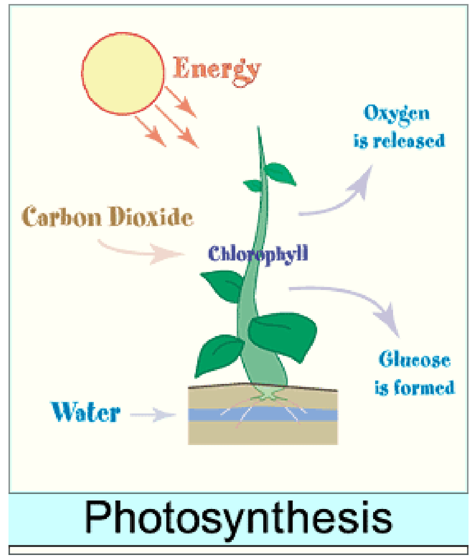
Lab Preparation

1. Teacher Prep before class starts:
    - You need a large plant to provide enough oxygen for the candle flame to remain lit longer. If time permits, it can be interesting to provide a variety of sizes of plants with which students can experiment.
    - It is important to have a good seal on the glass jar when it is over the plant and candle. This can be done with Vaseline (put Vaseline on the rim of the jar) or by putting pressure on the top of the glass.
2. Print out copies of the student worksheets.
3. Read over the Background Lesson Reading before teaching this class.
4. Watch the video for this experiment to prepare for teaching this class.

Background Lesson Reading

There are many steps to photosynthesis, but if we wanted to sum it up in one equation, it would be carbon dioxide (CO_2) + water (H_2O) makes glucose ($C_6H_{12}O_6$) and oxygen (O_2). These words can be written like this:

$6CO_2 + 6H_2O + \text{Light Energy} \rightarrow C_6H_{12}O_6 + 6O_2$



Carbon dioxide, water, and energy combine to form glucose and oxygen.

Glucose is a kind of sugar. This sugar is important for energy, so the plant stores all the glucose it creates. However, the plant releases the oxygen it creates.

Now we can see two reasons why photosynthesis is so important not just to plants, but to animals too. First, all animals need oxygen to live. Photosynthesis produces oxygen, so without this process, animals could not survive. Also, don't forget that since animals can't make their own food, they have to eat plants, or eat other animals that have eaten plants. So without plants, animals would quickly run out of food.

Lesson

1. Ask students to breathe in (and out!). Ask: "*What did we just breathe in?*"
2. Explain: *Oxygen is essential for animal (human) life, because we use it in respiration (breathing).*
3. Explain: *Plants "breathe out" oxygen, so they are essential for animal (ie human) life. More specifically, plants take in carbon dioxide, water and sunlight energy and produce glucose and oxygen. They keep the glucose for energy, but they release or "breathe out" the oxygen. Then animals breathe it in.*
4. Ask: *If something ran out of oxygen, how could we provide it with more?*
5. Explain: *Today, we are going to experiment with using plants to provide oxygen to fire (candle light).*
6. As a demonstration to the students, you can show how to tell if starch is present. Don't let the students handle the caustic soda – it's corrosive.
    a. Place the caustic soda on a disposable plate. **Don't get this on your hands or eyes – it's very corrosive. Handle this chemical ONLY with gloves and keep away from small children and pets like dogs and cats.**
    b. Place the caustic soda next to the plant and cover with the glass.
    c. Leave this setup undisturbed for a few hours.
    d. When you're done, take a leaf from the plant and do an iodine test on it to find out if there is starch present. Simply place a drop of iodine on the leaf. Iodine changes to dark blue when starch is present.

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. Light your candle.
4. Invert the glass over it and time how long it takes the candle to use up all the oxygen and extinguish itself. Write this number down in your journal.

5. Find a young plant or bush, preferably with a lot of growth and leaves. Place your candle next to the plant (don't burn your plant!) and invert the jar over it again.
6. Use your stopwatch to time how long the candle stays lit. Write this number down in your journal.
7. Which one do you expect to take longer? What actually happened?

Exercises

1. Describe the process of photosynthesis in words. (Carbon dioxide, water, and light energy combine to form glucose and oxygen.)
2. Write the chemical equation for photosynthesis. ($6CO_2 + 6H_2O$ + Light Energy –> $C_6H_{12}O_6 + 6O_2$)
3. What is glucose? (Glucose is a kind of sugar)
4. Why is glucose important for plants? (It gives energy to plants)
5. Why are plants necessary for animals? (Plants give off the oxygen produced in photosynthesis. Animals breathe in this oxygen. As well, animals eat plants or other animals that eat plants, so plants are also necessary for animal food).
6. Does the result of the experiment depend on how large the plant is? Why or why not? (Yes, if the plant is not large enough, it won't give off enough oxygen to keep the candle lit longer than if there were no plant inside of the glass)

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: Carbon Dioxide and Photosynthesis

Student Worksheet

Name____

Overview Photosynthesis is a process where light energy is changed into chemical energy. This process happens in the chloroplast of plant cells. Photosynthesis is one of the most important things that happen in cells. In fact, photosynthesis is considered one of the most important processes for all life on Earth. It makes sense that photosynthesis is really important to plants, since it gives them energy, but why is it so important to animals? In this lab, you will see evidence of plants giving off the oxygen animals need to survive.

What to Learn There are many steps to photosynthesis, but if we wanted to sum it up in one equation, it would be carbon dioxide (CO_2) + water (H_2O) makes glucose ($C_6H_{12}O_6$) and oxygen (O_2). These words can be written like this: $6CO_2 + 6H_2O$ + Light Energy –> $C_6H_{12}O_6 + 6O_2$

Carbon dioxide, water, and energy combine to form glucose and oxygen. Glucose is a kind of sugar. This sugar is important for energy, so the plant stores all the glucose it creates. However, the plant releases the oxygen it creates. Now we can see two reasons why photosynthesis is so important not just to plants, but to animals too. First, all animals need oxygen to live. Photosynthesis produces oxygen, so without this process, animals could not survive. Also, don't forget that since animals can't make their own food, they have to eat plants, or eat other animals that have eaten plants. So without plants, animals would quickly run out of food.

Materials

- candle
- lighter with adult help
- large glass jar
- stopwatch
- leafy plant (weeds work also)
- Optional: sodium hydroxide and iodine

Lab Time

1. Light your candle.
2. Invert the glass over it and time how long it takes the candle to use up all the oxygen and extinguish itself. Write this number down in your journal.
3. Find a young plant or bush, preferably with a lot of growth and leaves. Place your candle next to the plant (don't burn your plant!) and invert the jar over it again.
4. Use your stopwatch to time how long the candle stays lit. Write this number down in your journal.
5. Which one do you expect to take longer? What actually happened?
6. Create a Data Table.

Carbon Dioxide and Photosynthesis Data Table

Object Under the Glass	Time For Candle to Extinguish

Exercises Answer the questions below:

1. Describe the process of photosynthesis in words.

2. Write the chemical equation for photosynthesis.

3. What is glucose?

4. Why is glucose important for plants?

5. Why are plants necessary for animals?

6. Does the result of the experiment depend on how large the plant is? Why or why not?

Lesson #15: Einstein's Garden

Teacher Section

Overview During photosynthesis, plants take in energy from the sun (sunlight). They combine it with carbon dioxide and water. Einstein told us that energy can neither be created nor destroyed. In other words, the energy that plants take in remains with the plant. In this experiment, we will measure how much energy remains with the plant by weighing the plant each day.

Suggested Time 30-45 minutes

Objectives The germination, growth, and development of plants can be affected by light, gravity, touch, or environmental stress. Energy entering ecosystems as sunlight is transferred by producers into chemical energy through photosynthesis, and then from organism to organism in food webs. Living organisms are made of molecules largely consisting of carbon, hydrogen, nitrogen, oxygen, phosphorus and sulfur. Students will measure the effect of water and sunlight on the weight of a potted plant.

Materials (per lab group)

- scale for weighing your plant
- pot with soil
- plant (not potted yet)
- water
- time

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. Make sure students measure the amount of water they give their plant. Make sure that they water it with the same amount each day.

Background Lesson Reading

Mass and energy are conserved. This means you can't create or destroy them, but you can change their location or form. Most people don't understand that the energy term means *all* the energy transformations, not just the energy inside of the atom.

The energy could be burning gasoline, fusion reactions (like in the sun), metabolizing your lunch, elastic energy in a stretched rubber band… every kind of energy stored in the mass is what "energy" means.

For example, if I were to stretch a rubber band and somehow weigh it in the stretched position, I would find it weighed slightly more than in the unstretched position. Why? How can this be? I didn't add any more particles to the system – I simply stretched the rubber band. I added energy to the system, which was stored in the electromagnetic forces inside the rubber band, which add to the mass of the object (albeit very slightly).

For plants, this means that energy from captured sunlight, combined with carbon dioxide and water, both of which have mass, make the plant heavier. Let's find out how Einstein would have planted a garden while thinking about his big ideas.

Lesson

1. Ask: *What happens to our bodies when we eat food?* After some discussion, lead students to the idea that we gain weight, if they haven't come up with it.
2. Explain: *What do you think happens to a plant when it eats?*
3. Say: *That's right! It also gains weight.*
4. Explain: *But in this experiment, we aren't giving the plant food, so how is it gaining weight? Where is the food coming from?*
5. Brainstorm some student ideas.
6. Say: *Plants are actively taking in energy, just like we take in food. They take energy from the sun, and change it into sugar to eat. That is how it gains weight.*
7. Explain: *We are going to measure how much weight the plant gains, or how much sugar it takes in*.
8. Ask: How much weight do you think your plant will gain per day? per week?

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. Prepare a pot with dirt. Add a measured amount (like 1 cup) of water to dampen the soil. Weigh the pot filled with soil (but no plant).
4. Add a plant to the pot and weigh the whole thing.
5. Subtract the weight you found in step 1 from step 2 to find out how much the plant weighs.
6. You'll be weighing your pot each day. Weigh the plant before watering (water it the same amount each day) and write it down in your data table. If you're giving it water and sunlight, the plant should be getting heavier.
7. Make sure students measure the amount of water they give their plant. Make sure that they water it with the same amount each day.

Exercises

1. Where does this mass come from? You can't create mass, and yet the plant is getting heavier. How? (You and I get heavier when we eat food. You aren't giving the plant food, but it is getting food. How? Where does its food come from? The energy from the sun is changed to sugars during photosynthesis, increasing the mass of the plant).
2. Can energy be created? (no)
3. Can energy be destroyed? (no)

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: Einstein's Garden

Student Worksheet

Name____

Overview During photosynthesis, plants take in energy from the sun (sunlight). They combine it with carbon dioxide and water. Einstein told us that energy can neither be created nor destroyed. In other words, the energy that plants take in remains with the plant. In this experiment, we will measure how much energy remains with the plant by weighing the plant each day.

What to Learn Most people don't understand that energy means *all* the energy transformations, not just the energy inside of an atom. The energy could be burning gasoline, fusion reactions (like in the sun), metabolizing your lunch, elastic energy in a stretched rubber band… every kind of energy stored inside of mass is what energy means.

For plants, this means that energy from captured sunlight, combined with carbon dioxide and water, both of which have mass, make the plant heavier. Let's find out how Einstein would have planted a garden while thinking about his big ideas.

Materials

- scale for weighing your plant
- pot with soil
- plant (not potted yet)
- water
- time

Lab Time

1. Prepare a pot with dirt. Add a measured amount (like 1 cup) of water to dampen the soil. Weigh the pot filled with soil (but no plant).
2. Add a plant to the pot and weigh the whole thing.
3. Subtract the weight you found in step 1 from step 2 to find out how much the plant weighs.
4. You'll be weighing your pot each day. Weigh the plant before watering (water it the same amount each day) and write it down in your data table . If you're giving it water and sunlight, the plant should be getting heavier.

Einstein's Garden Data Table

Date	Weight	Total Change in Weight

Exercises Answer the questions below:

1. Where does this mass come from? You can't create mass, and yet the plant is getting heavier. How?

2. Can energy be created?

3. Can energy be destroyed?

Lesson #16: Onion Mitosis

Teacher Section

Overview Mitosis is part of the cell cycle, a larger process that living organisms use to repair damage, grow, or just maintain condition. Mitosis is the process of cell division for eukaryotes, or cells with nuclei. It is more complex than cell division for cells without nuclei (prokaryotes). In this experiment, we're going to figure out the time it takes for an onion cell to go through each of the four mitosis states.

Suggested Time 30-45 minutes

Objectives Cells divide to increase their numbers through a process of mitosis, which results in two daughter cells with identical sets of chromosomes. Students will learn and define the four stages of mitosis. Students will identify the four stages of mitosis in onion cells, using a microscope.

Materials (per lab group)

- Compound microscope with slides and coverslip
- Onion (the root tip, not the onion itself)
- Science journal

Lab Preparation

1. Teacher Prep before class starts:
    a. If the onion does not have roots, you can grow them over a period of a couple of days. Make sure this is done before students do the experiment. Place the bottom of an onion in a glass of water for a couple of days and you'll see the roots grow to the size you need (about 2 cm long).
    b. As far as the size of the cut, you'll want it to be thin enough that it appears translucent; otherwise you'll have a hard time seeing it through the compound microscope. A razor blade is a good tool for this – you can pre-slice these ahead of time and leave them in a shallow dish of water until you need them.
2. Print out copies of the student worksheets.
3. Read over the Background Lesson Reading before teaching this class.
4. Watch the video for this experiment to prepare for teaching this class.

Background Lesson Reading

In eukaryotes there is a nucleus, so a more complex process called mitosis is needed with cell division. Mitosis is divided into four parts, or phases:

Phase 1 – **Prophase:** In this phase the nuclear membrane begins to break down and the DNA forms structures called chromosomes.

Phase 2 – **Metaphase:** In this phase the chromosomes line up along the center of the parent cell

Phase 3 – **Anaphase:** In this phase, the chromosomes break apart, with a complete set of DNA going to each side of the cell

Phase 4 – **Telophase:** In this phase, a new nuclear membrane forms around each of the sets of DNA

The four stages of mitosis (the cell at the top has not started mitosis) lead to two daughter cells.

A little after telophase, the cytoplasm splits and a new cell membrane forms. Once again, two daughter cells have formed. Take a look at this animation for a good overview of mitosis and see if you can identify all the phases.

Cells continue to divide until a protein tells them to stop. As they divide, they become different and specialized, eventually making the tissues and organs found in the many different living things we see every day.

Lesson

1. Ask students what a cell might need to divide into two daughter cells.
2. Write some key words on the board: mitosis, nucleus, DNA, chromosomes, parent cell, daughter cell, nuclear membrane.
3. Explain: *Cells with nuclei are called eukaryotic. They divide by a process called mitosis.*
4. Explain: *Mitosis happens in a particular way: First, the cell membrane breaks down and DNA forms chromosomes; next, these chromosomes line up on either side of the parent cell, to get ready for division; third, the chromosomes break apart, each containing a complete set of DNA; finally, a new nuclear membrane forms around each set of DNA.*
5. Ask students to explain the process to their partner, using the vocabulary words on the board.
6. Explain that each stage has a particular name. Reiterate the process, this time using the proper terms for each phase: prophase, metaphase, anaphase, telophase.

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, set up your microscope.
4. Next, prepare an onion sample. Take it from the root tip called the meristematic zone, just above the root cap at the very end of the tip.
5. Use the staining technique we show in our Microscope Lab. Cut the sample lengthwise before placing it on the slide.

6. If you want to stop the cell division process while you watch the slide, you'll need to prepare a heat fix mount instead (make sure you don't boil the liquid when you use the candle or you'll ruin your slide). You can add a drop or two of stain after the heat fix and blot the excess with a paper towel. Add a drop of water and a coverslip and you're ready to look.
7. Try different powers of magnification to find the four different stages of mitosis. Count the number of cells found at each stage of mitosis and figure out the percentage. (Total up the number of cells and use this number to divide each count by. Don't forget to multiply by 100 for percentage!)

Exercises

1. What is mitosis? (The process of cell division for eukaryotes. It is used for cell repair, growth or maintenance.)
2. What are the four stages of mitosis? (Stage 1: Prophase—nuclear structure breaks down and DNA forms chromosomes; Stage 2: Metaphase—chromosomes line up along center of the parent cell; Stage 3: Anaphase —chromosomes break apart with a complete set of DNA going to each side of the cell; Stage 4: Telophase—a new nuclear membrane forms around each new set of DNA)
3. Out of all four stages of mitosis, which one takes the most time to complete? The shortest time? What happens to the process if we skip metaphase? (Prophase. Anaphase. The chromosomes wouldn't line up, so cell division would be unsuccessful.)

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: Onion Mitosis

Student Worksheet

Name____

Overview Mitosis is part of the cell cycle, a larger process that living organisms use to repair damage, grow, or just maintain condition. In this experiment, we're going to figure out the time it takes for an onion cell to go through each of the four mitosis states.

What to Learn Mitosis is divided into four parts, or phases:

Phase 1 – **Prophase:** In this phase the nuclear membrane begins to break down and the DNA forms structures called chromosomes.

Phase 2 – **Metaphase:** In this phase the chromosomes line up along the center of the parent cell

Phase 3 – **Anaphase:** In this phase, the chromosomes break apart, with a complete set of DNA going to each side of the cell

Phase 4 – **Telophase:** In this phase, a new nuclear membrane forms around each of the sets of DNA

The four stages of mitosis (the cell at the top has not started mitosis) lead to two daughter cells.

Materials

- Compound microscope with slides and coverslip
- Onion (the root tip, not the onion itself) – you can grow your own if you can't find any at the store. Place the bottom of an onion in a glass of water for a couple of days and you'll see the roots grow to the size you need (about 2 cm long).
- Science journal

Lab Time

1. First, set up your microscope.
2. Next, prepare an onion sample. Take it from the root tip called the meristematic zone, just above the root cap at the very end of the tip.
3. Use the staining technique we show in our Microscope Lab. Cut the sample lengthwise before placing it on the slide.
4. If you want to stop the cell division process while you watch the slide, you'll need to prepare a heat fix mount instead (make sure you don't boil the liquid when you use the candle or you'll ruin your slide). You can add a drop or two of stain after the heat fix and blot the excess with a paper towel. Add a drop of water and a coverslip and you're ready to look.

5. Try different powers of magnification to find the four different stages of mitosis. Count the number of cells found at each stage of mitosis and figure out the percentage. (Total up the number of cells and use this number to divide each count by. Don't forget to multiply by 100 for percentage!)
6. Draw what you see through the microscope and label each sketch:

Exercises Answer the questions below:

1. What is mitosis?

2. What are the four stages of mitosis? Briefly describe what happens in each.

3. Out of all four stages of mitosis, which one takes the most time to complete? The shortest time? What happens to the process if we skip metaphase?

Lesson #17: Terraqua Column

Teacher Section

Overview How does salt affect plant growth, like when we use salt to de-ice snowy winter roads? How does adding fertilizer to the soil help or hurt the plants? What type of soil best purifies the water? All these questions and more can be answered by building a terrarium-aquarium system that are connected together.

Suggested Time 30-45 minutes

Objectives Students will measure the effects of various water solutions and soil types on plants and animals in a terraqua column. Plants and animals both need water; animals need food, and plants need light.

Materials (per lab group)

- two 2-liter soda bottles, empty and clean
- two bottle caps
- scissors and razor with adult help
- thin rope for wick, about 5 in long
- tape
- water, soil, and plants

Lab Preparation

1. Helpful hints for the teacher:
    - Pre-drill a hole in the center of one bottle cap per group. The hole should be just big enough to fit the wick through.
    - Adult help will be needed for the razor cutting. You may want to pre-slice into the bottles to provide a starting point for students to cut with scissors.
    - Make sure that students have a control terraqua column. For example, if they are testing the effect of salt on plant growth by putting saltwater in the reservoir, they will also need a terraqua column with fresh water in it as well.
2. Print out copies of the student worksheets.
3. Read over the Background Lesson Reading before teaching this class.
4. Watch the video for this experiment to prepare for teaching this class.

Background Lesson Reading

Water drips off the roof of your house, down your driveway, over your toothbrush and down the sink, through farm fields, and into rivers, lakes and oceans. While traveling, this water picks up litter, nutrients, salts, oil, and also gets purified by running through soil. All of this has an affect on fish and animals that live in the oceans. The question is, how does it affect the marine ecosystem? That's what this experiment will help you discover.

Land and aquatic plants are excellent indicators of changes in your terraqua system. By using fast-germinating plats, you'll see the changes in a relatively short about of time. You can also try grass seeds (lawn mixes are good, too), as well as radishes and beans. Pick seeds that have a life cycle of less than 45 days.

How to Care for your TAC (Terra-Aqua Column) EcoSystem:

- Keep the TAC out of direct sunlight.
- Keep your cotton ball very wet using only distilled water. Your plants and triops are very sensitive to the kind of water you use.
- Feed your triops once they hatch (see below for instructions)
- Keep an eye on plant and algae growth (see below for tips)

About the plants and animals in your TAC:

Carnivorous plans are easy to grow in your TAC, as they prefer warm, boggy conditions, so here are a few tips: keep the TAC out of direct sunlight but in a well-lit room. Water should condense on the sides of the column, but if lots of black algae start growing on the soil and leaves, poke more air holes! Water your soil with distilled water, or you will burn the roots of your carnivorous plants. Trim your plants if they crowd your TAC.

If you run out of **fruit flies**, place a few slices of banana or melon in an aluminum cup or milk jig lid at the bottom of a soda bottle (which has the top half cut off). Invert the top half and place it upside down into the bottom part so it looks like a funnel and seal with tape so the flies can't escape. Make a hole in the cap small enough so only one fly can get through. The speed of a fruit fly's life cycle (10-14 days) depends on the temperature range (75-80 degrees). Transfer the flies to your TAC. If you have too many fruit flies, discard the fruit by putting it outside (away from your trash cans) or flush it down the toilet.

You can't feed a **praying mantis** too much, and they must have water at all times. You can place 2-3 baby mantises in a TAC at one time with the fruit flies breeding below. When a mantis molts, it can get eaten by live crickets, so don't feed if you see it begin to molt. When you see wings develop, they are done fully mature. Adult mantises will need crickets, houseflies, and roaches in addition to fruit flies.

Baby **triops** will hatch in your TAC aquarium. The first day they do not need food. Crush a green and brown pellet and mix together. Feed your triop half of this mixture on the 2^{nd} and the other half on the 4^{th} day (no food on day 3). After a week, feed one pellet per day, alternating between green and brown pellets. You can also feed them shredded carrot or brine shrimp to grow them larger. If you need to add water (or if the water is too muddy), you can replace half the water with fresh, room temperature distilled water. You can add glowing beads when your triop is 5 days old so you can see them swimming at night (poke these through the access hole).

Lesson

1. Ask students: *What do plants need to survive?*
2. Make a list of their ideas on a T-chart.
3. Ask students: *What do animals need to survive*?
4. Make a list of those ideas on the T-chart.
5. Explain: *Plants need water, soil and sunlight. Animals need food and water.*
6. Ask students to imagine a way that plants, animals and water could be put into a container to survive together.
7. Explain that students are going to make a terrarium-aquarium, or terraqua column in one! In this terraqua column, the water will be in a reservoir in the bottom, while soil and plants will be in the middle chambers. Animals will be added
8. Explain that we can change elements of the terraqua column to explore the relationship between land and water. For example, we could put different types of water in the terraqua column.

9. Ask students: *Do you think salt has an effect on plants?*
10. Explain: *In order to test if salt has an effect, we can make a terraqua column with salt water, and observe the differences it makes in the plants and animals in the terraqua column.*
11. Have students test their hypothesis in the lab below.

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 bottle #1 below the shoulder (at the top, where it begins to curve). Start the cut with the razor, then finish with the scissors. This cut will give you two pieces.
4. Screw the cap on top.
5. Drill a hole in the center of the cap, while it is on the bottle. Set the two parts aside.
6. Cut bottle #2 below the hip of the bottle (at the bottom, where it goes from straight to curvy). Set the bottom piece aside.
7. Screw cap on the long part of the bottle.
8. Fill the reservoir of the first bottle with water.
9. Tie a knot at one end of the wick.
10. Put the wick through the cap with the hole (bottle #1).
11. Invert the section with the cap with the hole and set it in the reservoir. This the chamber where the plants will go.
12. Finally, put the section with the cap with no hole on the very top of the terraqua column.

Exercises

1. What three things do plants need to survive? (*water, soil, light*)
2. What two things do animals need to survive? (*food, water*)
3. Does salt affect plants? How? (*answers may vary according to student level. Students may simply say that plants wilt or die. Salt dissolves in water, causing water to be highly concentrated. Water then actually moves out of the plant, because it moves from areas of high concentration to areas of low concentration. Plants thus wilt.*)

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: Terraqua Column

Student Worksheet

Name____

Overview Water drips off the roof of your house, down your driveway, over your toothbrush and down the sink, through farm fields, and into rivers, lakes and oceans. While traveling, this water picks up litter, nutrients, salts, oil, and also gets purified by running through soil. All of this has an affect on fish and animals that live in the oceans. The question is, how does it affect the marine ecosystem? That's what this experiment will help you discover.

What to Learn In this experiment, you will explore the relationship between land and water by constructing a terraqua colum (a terrarium and an aquarium in one). You will measure the effects of different types of water and soil on the ecosystem in the terraqua column.

What happens to the plants and animals when you put freshwater in the reservoirs? Saltwater? What happens to the plants and animals when you put different kinds of soil in the terraqua column?

Materials

- two 2-liter soda bottles, empty and clean
- two bottle caps
- scissors and razor with adult help
- Drill and drill bit with adult help
- tape
- thin rope for a wick, about 5 in long
- water, soil, and plants

Lab Time

1. Cut bottle #1 below the shoulder (at the top, where it begins to curve). Start the cut with the razor, then finish with the scissors. This cut will give you two pieces.
2. Screw the cap on top.
3. Drill a hole in the center of the cap, while it is on the bottle. Set the two parts aside.
4. Cut bottle #2 below the hip of the bottle (at the bottom, where it goes from straight to curvy). Set the bottom piece aside.
5. Screw cap on the long part of the bottle.
6. Fill the reservoir of the first bottle with water.
7. Tie a knot at one end of the wick.
8. Put the wick through the cap with the hole (bottle #1).
9. Invert the section with the cap with the hole and set it in the reservoir. This is the chamber where the plants will go.
10. Finally, put the section with the cap with no hole on the very top of the terraqua column.
11. Create a data table.

Terraqua Column Data Table

Variable	Effect
Fresh Water	
Saltwater	

Exercises Answer the questions below:

1. What three things do plants need to survive?

2. What two things do animals need to survive?

3. Does salt affect plants? How?

Lesson #18: Who Eats Whom?

Teacher Section

Overview The way animals and plants behave is so complicated because it not only depends on climate, water availability, competition for resources, nutrients available, and disease presence but also having the patience and ability to study them close-up. We're going to build an eco-system where you'll farm prey stock for the predators so you'll be able to view their behavior. You'll also get a chance to watch both of them feed, hatch, molt, and more! You'll observe closely the two different organisms and learn all about the way they live, eat, and are eaten.

Suggested Time 30-45 minutes

Objectives : Animals eat plants or other animals for food and may also use plants or even other animals for shelter and nesting. Producers and consumers (herbivores, carnivores, omnivores, and decomposers) are related in food chains and food webs, and may compete with each other for resources in an ecosystem. Over time, matter is transferred from one organism to others in the food web, and between organisms and the physical environment. Students will observe how insects such as praying mantises and fruit flies live, eat and are eaten.

Materials (per lab group)

- four 2-liter soda bottles, empty and clean
- 2 bottle caps
- one plastic lid that fits inside the soda bottle
- small piece of fruit to feed fruit flies
- aluminum foil
- plastic container with a snap-lid (like an M&M container or film can)
- scissors and razor with adult help
- tape
- ruler
- predators: spiders OR praying mantis OR carnivorous plants (if you're using carnivorous plants, make sure you do this Carnivorous Greenhouse experiment first so you know how to grow them successfully)
- soil, twigs, small plants

Lab Preparation

1. Teacher Prep before class starts:
   a. Fruit Fly Trap: If you find you've got way too many fruit flies, you might want to trap them instead of breed them. Remove the foil buckets every 4-7 days or when you see larvae on the fruit, and replace with fresh ones and toss the fruit away. Don't toss the larvae in the trash, or you'll never get rid of them from your trash area! Put them down the drain with plenty of water.
   b. Predator-Prey Column: You can use carnivorous plants, small spiders, or praying mantises. If you use plants, choose venus flytraps, sundews, or butterworts and make sure your soil is boggy and acidic. You can add a bit of activated charcoal to the soil if you need to change the pH. Since the plants like warm, humid environments, keep the soil moist enough for water to fog up the inside on a regular basis. You know you've got too much moisture inside if you find algae on the plants and dirt. (If this happens, poke a couple of air holes.) Don't forget to only use distilled water for the carnivorous plants!
   c. Keep the column out of direct sunlight so you don't cook your plants and animals.

d. You can capture praying mantis but it is best to raise them. You can order eggs online.
e. Hatchlings need water within the first 12 hours
f. When you fill the upper compartment, make sure that it is moist and that there are structural things for the mantis to climb on, such as sticks or twigs.
g. As Mantis grow, they eat a lot, so keep the prey chamber full. As they grow, they also need larger prey, such as flies, crickets or cockroaches.

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

Background Lesson Reading

Organisms that might be in your Predator-Prey Column

Insects are not only the most diverse subgroup of arthropods, but with over a million discovered species it is the most diverse group of animals on earth. Although they can't all be as beautiful as a butterfly, they all play important roles in their ecosystems—just think of where we would be without bees!

The segmented exoskeletons of insects have a hard, inner layer called the **cuticle**, and a water-resistant outside layer called the **exocuticle**. Insects are divided into two major groups: **winged insects** and**wingless insects**. Air is taken in through structures called **spirials**, and delivered directly to the body. Most insects are**oviparous** (hatch from eggs after the eggs are laid).

The praying mantis has a long neck and a triangular head that can turn 180 degrees to search for their prey. They have two large compound eyes and three other simple eyes between them. They are built for "preying!" They use their front legs to capture their prey, and the spikes on their legs to hold their food in place.

Did you know that fruit flies don't really eat fruit? They actually eat the yeast that growing on the fruit. Fruit flies actually bring the yeast with them on the pads of their feet and spread the yeast to the fruit so that they can eat it. You can tell if a fruit fly has been on your fruit because yeast has begun to spread on the skin.

Lesson

1. Ask: *If I catch a bug such as a praying mantis, and keep it in a jar, what will it need to live?*
2. Brainstorm answers on the board. Sort answers into categories: food, water, shelter, air.
3. Explain: *If I have an insect such as a fruit fly in a jar, what would it need to survive?*
4. Say: *That's right…fruit!*
5. Explain: *We are going to make a jar that has both! The praying mantis eats fruit flies, and fruit flies need fruit to survive.*
6. Define terms: *We call the praying mantis a predator, and the fruit fly, prey. Together, they form a system called an eco-system. The fruit flies get energy from the fruit, the praying mantis then gets energy from the fruit fly.*
7. Explain: *The predator needs the prey to survive, so it evolves whatever it needs to catch the prey. The prey is part of the predator's ecosystem, so it develops whatever it needs to avoid being eaten. Each one develops physical traits, habits, and behavior to help it survive. You will observe these in this predator-prey column.*

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.

How to Make the Fruit Fly Trap:

3. Cut bottle below the shoulder. (Start cut with a razor, finish with scissors, with adult help.)
4. Screw cap on tight.
5. Drill a hole in center of cap.
6. Set a lid in the bottom of the bottle.
7. Cover the cap with a piece of foil to begin forming a little cup. Remove the foil and finish forming into a cup.
8. Make three foil cups and place a piece of fruit in each.
9. Place cups on the lid at the bottom of the bottle.
10. Slide the top of the bottle in upside down.
11. Tape to seal around the rim of the fruit fly trap.

How To Make the Predator-Prey Column

12. Cut bottle #1 above the shoulder. (Start cut with a razor, finish with scissors, with adult help.)
13. Cut bottle #1 below the hip.
14. Cut bottle #2 one pinkie's width lower than the shoulder.
15. Put the cap on bottle#2
16. Drill a 4 mm hole into the cap of bottle #2.
17. Cut 1 finger above the hip on bottle #2.
18. Measure 4 cm above the hip on bottle #3 and cut.
19. Take bottle #1 middle part and slide the top of bottle#2 into it upside down.
20. Measure 4 mm up from the bottom on bottle #3 and cut.
21. Set #11 above (bottle#1 middle and top of bottle#2) into #12 above (bottom of bottle#3).
22. Put the shorter base on top of the whole structure.
23. Poke air holes in the top.

To Make the Water Feeder

24. Drill a hole in the bottom of the vial (with adult help).
25. Insert the wick into the hole.
26. Tie a knot in the part of the wick that is inside the vial, to plug the hole.
27. Drill a hole in the side of the predator prey column. Put the wick through the hole and attach the vial to the bottle with tape.
28. Keep the vial filled with water.
29. Place the tray that is in the bottom of the fruit fly trap in the bottom of the predator prey column. Remember to do this outside.
30. Put plants and spiders in the top portion of the predator-prey column.

Exercises

1. What shape is the head of the mantis? (triangular)
2. How many eyes does a praying mantis have? (two compound and three simple. Five total)

3. How else has the mantis head evolved to stalk their prey? (their head can turn 180 degrees)
4. How does a praying mantis hold its food? (with its front, spiky legs)
5. Do fruit flies eat fruit? (No, they eat the yeast that grows on fruit.)
6. How do predators and prey change over time? (they develop physical traits and behaviors to help them survive (ie eat or avoid being eaten))

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: Who Eats Whom?

Student Worksheet

Name____

Overview The way animals and plants behave is so complicated because it not only depends on climate, water availability, competition for resources, nutrients available, and disease presence but also having the patience and ability to study them close-up.

We're going to build an eco-system where you'll farm prey stock for the predators so you'll be able to view their behavior. You'll also get a chance to watch both of them feed, hatch, molt, and more! You'll observe closely the two different organisms and learn all about the way they live, eat, and are eaten.

What to Learn Predators and prey are necessary for each other's ecosystem. They each evolve physical characteristics and behaviors for survival. It can be difficult to observe such a small system, so the Predator-Prey column allows us to see mantises eating fruit flies, and fruit flies breaking down fruit.

The praying mantis has a long neck and a triangular head that can turn 180 degrees to search for their prey. They have two large compound eyes and three other simple eyes between them. They are built for "preying!" They use their front legs to capture their prey, and the spikes on their legs to hold their food in place.

Did you know that fruit flies don't really eat fruit? They actually eat the yeast that growing on the fruit. Fruit flies actually bring the yeast with them on the pads of their feet and spread the yeast to the fruit so that they can eat it. You can tell if a fruit fly has been on your fuit because yeast has begun to spread on the skin.

Materials

- four 2-liter soda bottles, empty and clean
- 2 bottle caps
- one plastic lid that fits inside the soda bottle
- small piece of fruit to feed fruit flies
- aluminum foil
- plastic container with a snap-lid (like an M&M container or film can)
- scissors and razor with adult help
- tape
- ruler
- predators: spiders OR praying mantis OR carnivorous plants (if you're using carnivorous plants, make sure you do the Carnivorous Greenhouse experiment first so you know how to grow them successfully)
- soil, twigs, small plants

Lab Time

To Make Fruit Fly Trap

1. Cut bottle below the shoulder. (Start cut with a razor, finish with scissors, with adult help.)
2. Screw cap on tight.
3. Drill a hole in center of cap.
4. Set a lid in the bottom of the bottle.
5. Cover the cap with a piece of foil to begin forming a little cup. Remove the foil and finish forming into a cup.
6. Make three foil cups and place a piece of fruit in each.
7. Place cups on the lid at the bottom of the bottle.
8. Slide the top of the bottle in upside down.
9. Tape to seal around the rim of the fruit fly trap.

To Make the Predator-Prey Column

10. Cut bottle #1 above the shoulder. (Start cut with a razor, finish with scissors, with adult help.)
11. Cut bottle #1 below the hip.
12. Cut bottle #2 one pinkie's width lower than the shoulder.
13. Put the cap on bottle#2
14. Drill a 4 mm hole into the cap of bottle #2.
15. Cut 1 finger above the hip on bottle #2.
16. Measure 4 cm above the hip on bottle #3 and cut.
17. Take bottle #1 middle part and slide the top of bottle#2 into it upside down.
18. Measure 4 mm up from the bottom on bottle #3 and cut.
19. Set #11 above (bottle#1 middle and top of bottle#2) into #12 above (bottom of bottle#3).
20. Put the shorter base on top of the whole structure.
21. Poke air holes in the top.

To Make the Water Feeder

22. Drill a hole in the bottom of the vial (with adult help).
23. Insert the wick into the hole.
24. Tie a knot in the part of the wick that is inside the vial, to plug the hole.
25. Drill a hole in the side of the predator prey column. Put the wick through the hole and attach the vial to the bottle with tape.
26. Keep the vial filled with water.
27. Place the tray that is in the bottom of the fruit fly trap in the bottom of the predator prey column. Remember to do this outside.
28. Put plants and spiders in the top portion of the predator-prey column.

29. Draw a complete diagram of both apparatus (Fruit Fly Trap and the Predator-Prey Column), labeling each part:

Exercises Answer the questions below:

1. What shape is the head of the mantis?
2. How many eyes does a praying mantis have?
3. How else has the mantis head evolved to stalk their prey?
4. How does a praying mantis hold its food?
5. Do fruit flies eat fruit?
6. How do predators and prey change over time?

Lesson #19: Insect Aspirator

Teacher Section

Overview Some insects are just too small! Even if we try to carefully pick them up with forceps, they either escape or are crushed. What to do?

Answer: Make an insect aspirator! An insect aspirator is a simple tool scientists use to collect bugs and insects that are too small to be picked up manually. Basically it's a mini bug vacuum!

Suggested Time 30-45 minutes

Objectives : Students will create a small aspirator to catch tiny insects, observe and record their behavior.

Materials (per lab group)

- A small vial or test tube with a (snug fitting) two-holed rubber stopper. OR a plastic water bottle with a cap.
- Two short pieces of stiff plastic tubing. We'll call them tube A and tube B. OR two bendy straws.
- Fine wire mesh (very small holes because this is what will stop the bugs from going into your mouth!)
- A cotton ball.
- One to two feet of flexible rubber tubing.
- Duct tape or a rubber band or hot glue
- razor, with adult help
- Drill with drill bit, with adult help

Lab Preparation

1. Teacher Prep before class starts:
    - Pre drill bottle cap.
    - If the bugs aren't being pulled into the vial, the suction may not be strong enough. Remove the cotton ball and try again. If it still is not working check to make sure the aspirator is air-tight (is the stopper fitting snuggly into the vial? Are there cracks/holes around or in the plastic tubes?).
    - Make sure your wire mesh is very fine (the holes are smaller than the bugs you're trying to collect). Otherwise you may be inhaling a bug you don't want!
2. Print out copies of the student worksheets.
3. Read over the Background Lesson Reading before teaching this class.
4. Watch the video for this experiment to prepare for teaching this class.

Lesson

1. Ask students to think of a machine that sucks things up: Vaccuum.
2. Ask: *What happens if we want to vacuum a large rug. What type of vacuum would we need?* An industrial (Big) one.
3. Ask: *What if we just want to vacuum up some crumbs on the counter and be able to find them in the vacuum, would we use a large or small vacuum?* Small.
4. Explain: *Today we are going to make a small vacuum to suck up tiny insects so that we can observe them. Our small vacuum is called an aspirator.*

5. Explain: *Be careful! Our machine does not plug in, so you will provide the suction power: you will "suck up" the bugs!*
6. Show a sample aspirator, and show how to suck up a piece of paper.
7. Explain that the suction power is done through one straw, while the other straw is the tube where the bugs will be sucked into. In order not to suck up the bugs and be able to catch them, we need this second tube, which leads into the bottle (place where we can catch and observe them).

Lab Time

1. Insert the tube A and Tube B into the stopper such that the stopper is in the middle of both pieces.
2. Bend both A and B plastic tubing 90 degrees away from each other. Their ends should be pointing away from each other.
3. Cut a square of mesh large enough to the end of the plastic tubing. Tape (or rubber-band) the mesh over bottom of tube A only. Remember, if you cover both of the tubes the bugs won't be able to enter the aspirator.
4. Insert a small amount of cotton ball into the other side of tube A (not enough to block airflow, just enough to help filter the dust and particles entering the vial.
5. Cut another piece of mesh and cover the other end of Tube A. Secure that mesh with another piece of tape/rubber band.
6. Fit the rubber tubing over the top of tube B (the bent side).
7. Fit the stopper into the vial/test tube.
8. To use the aspirator, hold the end of the rubber tubing near the insects you want to collect, and suck through the top of tube A. The vacuum you create sucks the insects into the vial/test tub (make sure they can fit in the tube!).

Exercises

1. Why don't we use a large vacuum to suck up the bugs? (It is too large. The insects would be nearly impossible to see)
2. Why do we need a small mesh covering on the end of the straw that we suck on? (So as not to suck up the bugs!)
3. Why do we need to be careful about catching ants? (They emit formic acid.)
4. What insects did you catch that you rarely see? (answers may vary.)
5. What familiar insects did you catch? (answers may vary).

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: Insect Aspirator

Student Worksheet

Name____

Overview Some insects are just too small! Even if we try to carefully pick them up with forceps, they either escape or are crushed. What to do?

Answer: Make an insect aspirator! An insect aspirator is a simple tool scientists use to collect bugs and insects that are too small to be picked up manually. Basically it's a mini bug vacuum!

What to Learn In this lab, you will learn to use suction power (your own sucking power!) to suck up (but not inhale!) tiny insects. You will learn the behavior of tiny insects that are difficult to observe because they are so small.

Materials

- A small vial or test tube with a (snug fitting) two-holed rubber stopper. OR a plastic water bottle with a cap.
- Two short pieces of stiff plastic tubing. We'll call them tube A and tube B. OR two bendy straws.
- Fine wire mesh (very small holes because this is what will stop the bugs from going into your mouth!)
- A cotton ball.
- One to two feet of flexible rubber tubing.
- Duct tape or a rubber band or hot glue

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. Insert the tube A and Tube B into the stopper such that the stopper is in the middle of both pieces.
4. Bend both A and B plastic tubing 90 degrees away from each other. Their ends should be pointing away from each other.
5. Cut a square of mesh large enough to the end of the plastic tubing. Tape (or rubber-band) the mesh over bottom of tube A only. Remember, if you cover both of the tubes the bugs won't be able to enter the aspirator.
6. Insert a small amount of cotton ball into the other side of tube A (not enough to block airflow, just enough to help filter the dust and particles entering the vial.
7. Cut another piece of mesh and cover the other end of Tube A. Secure that mesh with another piece of tape/rubber band.
8. Fit the rubber tubing over the top of tube B (the bent side).
9. Fit the stopper into the vial/test tube.
10. To use the aspirator, hold the end of the rubber tubing near the insects you want to collect, and suck through the top of tube A. The vacuum you create sucks the insects into the vial/test tube (make sure they can fit in the tube!).

Exercises Answer the questions below:

1. Why don't we use a large vacuum to suck up the bugs?

2. Why do we need a small mesh covering on the end of the straw that we suck on?

3. Why do we need to be careful about catching ants?

4. What insects did you catch that you rarely see?

5. What familiar insects did you catch? (answers may vary).

Lesson #20: Berlese Funnel

Teacher Section

Overview Unsurprisingly, often the most interesting critters found in soil are the hardest to find! They're small, fast, and used to avoiding things that search for them. So, how do we find and study these tiny insects? With a Berlese Funnel (Also called the Tullgren funnel)!

Suggested Time 30-45 minutes

Objectives : Students will observe the effect of heat on insects while making a Berlese funnel.

Materials (per lab group)

- 1 gallon tractor funnel.
- Clothespins.
- A light fixture that fits on top of the funnel and has a reflective interior.
- A bucket that has a smaller diameter than the top of the funnel. The funnel needs to be suspended from the bucket so the insects can fall into the jar.
- A clean jam-jar.
- Rubbing alcohol.
- ¼ inch wire mesh.
- Light bulb. The wattage has to be high enough to heat the soil, but not so high that it will light the funnel on fire. Best to do it by trial and error with lots of supervision.
- Soil. The best will be from a compost pile.

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the videos for this experiment to prepare for teaching this class.
4. Make a funnel to use as a sample for the students to view.

Background Lesson Reading

The funnel separates the insects from the soil with heat. A light bulb heats the soil at one end of a funnel and causes the insects to migrate, through mesh, to a preservative liquid at the other end of the funnel. Originally Antonio Berlese used a hot water bottle to provide the heat. Later, Albert Tullgren modified the funnel to work with a light bulb. Thus, we now call it the Berlese Funnel, the Tullgren Funnel, or the Berlese-Tullgren Funnel.

How the funnel works: The light creates heat. The insects in the soil don't like heat, so they move from the soil through the funnel into the jar. The jar is filled with rubbing alcohol preserves the specimens. The wire keeps most of the soil from falling into the jar.

Lesson

1. Ask: *What would happen if I were to turn the heater on full blast in this room, making it really, really hot?*
2. Say: *That's right! Most of us would leave the room*.
3. Explain: *Today, we are going to do the same thing to bugs, but we are going to imagine that there is only one door in the "hot room" and we are going to make it lead into another, cooler "room." When they are in the second "room" we will be able to observe them!*
4. Explain "*There are many insects that live in soil, but they are difficult to observe in the dark soil, and they don't often come out of the soil. Today we are going to observe them after we 'heat them out'."*
5. Show the funnel, and explain that this is like the first "hot" room. This is where we will put the soil.
6. Show the bottom of the bottle, and explain that this is the second "cool" room, where the bugs will end up and where we will observe them.
7. Show the light source, and explain that this is the unbearable heat.
8. A Berlese funnel is different from a light trap. The second video shows how to make a light trap so you can show the students the difference between the two and the kinds of insects they both attract.

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 a large hole in the side of the bucket. This will allow you to retrieve the jar without disassembling the apparatus. Naturally, the hole should be larger than the jar.
4. Fit the wire mesh so that it covers the bottom third of the funnel.
5. Fit the funnel on top of the bucket.
6. Fit the light fixture (with the light bulb in it) on top of the funnel with the clothespin.
7. Place the jar underneath the funnel (with or without the rubbing alcohol depending on if you want the specimens dead or alive).
8. *How to use the funnel:* Simply turn on the light and wait. Check the vial every fifteen minutes or so for an hour. After you have finished remember to turn off the light! Also, remember that some of the specimens may be very small and best observed under a microscope. For the best results do it in the morning or on a cold day.

Troubleshooting: What if there still aren't any bugs after an hour? If this happens, don't panic. Ask yourself these questions:

1. Is the light strong enough? If the light is not strong enough (i.e. generating enough heat), then the soil will not get hot enough to push the insects into the jar. The funnel works by creating a gradient of heat which the bugs move down into the jar. If the light isn't creating that gradient, no critters will feel like moving.
2. Is it hot today? If the sun is out and making everything hot, then the light will not make enough of a difference in heat—there will not be a heat gradient to move down. If so, don't worry; just try again the next morning.
3. Is there a problem with the funnel? Is the nozzle of the funnel too far from the mouth of the jar? Make sure that the specimens are falling *into* the jar and not *around* it. Is the mesh wire too fine? You want mesh that will keep most of the soil in the funnel, but not so fine that it will stop the bugs from getting through.
4. Lastly, are there any bugs in the soil? Not just any dirt will do for this project. You need soil rich with life! The best place to find this type of soil is near/in a compost pile (after it has become soil).

Exercises

1. Why are some insects difficult to find in soil? (Because it is too dark and they are too small.)
2. Why does the Berlese Funnel work to find insects? (Because it makes the temperature too hot for insects, so they seek a cooler space.)
3. What if the insects do not respond to the heat lamp in your experiment? (The heat may not be hot enough to create a temperature difference between the cooler space and the soil under the lamp.)
4. What types of insects were you able to find using the Funnel? (answers may vary)

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: Berlese Funnel

Student Worksheet

Name____

Overview Unsurprisingly, often the most interesting critters found in soil are the hardest to find! They're small, fast, and used to avoiding things that search for them. So, how do we find and study these tiny insects? With a Berlese Funnel (Also called the Tullgren funnel)!

What to Learn The funnel separates the insects from the soil with heat. A light bulb heats the soil at one end of a funnel and causes the insects to migrate, through mesh, to a preservative liquid at the other end of the funnel. Originally Antonio Berlese used a hot water bottle to provide the heat. Later, Albert Tullgren modified the funnel to work with a light bulb. Thus, we now call it the Berlese Funnel, the Tullgren Funnel, or the Berlese-Tullgren Funnel.

How the funnel works: The light creates heat. The insects in the soil don't like heat, so they move from the soil through the funnel into the jar. The jar is filled with rubbing alcohol preserves the specimens. The wire keeps most of the soil from falling into the jar.

Materials

- 1 gallon tractor funnel.
- Clothespins.
- A light fixture that fits on top of the funnel and has a reflective interior.
- A bucket that has a smaller diameter than the top of the funnel. The funnel needs to be suspended from the bucket so the insects can fall into the jar.
- A clean jam-jar.
- Rubbing alcohol.
- ¼ inch wire mesh.
- Light bulb. The wattage has to be high enough to heat the soil, but not so high that it will light the funnel on fire. Best to do it by trial and error with lots of supervision.
- Soil. The best will be from a compost pile.

Lab Time

1. Cut a large hole in the side of the bucket. This will allow you to retrieve the jar without disassembling the apparatus. Naturally, the hole should be larger than the jar.
2. Fit the wire mesh so that it covers the bottom third of the funnel.
3. Fit the funnel on top of the bucket.
4. Fit the light fixture (with the light bulb in it) on top of the funnel with the clothespin.
5. Place the jar underneath the funnel (with or without the rubbing alcohol depending on if you want the specimens dead or alive).
6. Simply turn on the light and wait. Check the vial every fifteen minutes or so for an hour. After you have finished remember to turn off the light! Also, remember that some of the specimens may be very small and best observed under a microscope. For the best results operate your funnel in the morning or on a cold day.

7. Draw a diagram of the different parts of your funnel and label each part:

Exercises Answer the questions below:

1. Why are some insects difficult to find in soil?
2. Why does the Berlese Funnel work to find insects?
3. What if the insects do not respond to the heat lamp in your experiment?
4. What types of insects were you able to find using the Funnel?

Lesson #21: Waterscope

Teacher Section

Overview Tide pools are best observed undisturbed. But, they're too shallow to snorkel… So how to can we explore them without removing their inhabitants? With an Aquascope! Aquascopes are very cheap and easy to make. With only a coffee can, some plastic food rap, and a couple of other items you can make a window into the world of tide-pools! In principle, aquascopes allow us to take a glass-bottom-boat tour of the rich ecosystems of tide pools. The plastic acts as the glass, while the coffee can allows us to break the distorting surface of the water.

Suggested Time 30-45 minutes

Objectives Students will understand the simple optics of a waterscope (also called an aquascope), and use it to observe organisms in water.

Materials (per lab group)

- milk or juice jug
- plastic wrap
- scissors
- rubber band

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't see clearly underwater with just your eyes for a couple of reasons. One is the thickness of the lens on your eye, but the main one is the index of refraction of water is different than that of air. Light rays bend when they travel from one medium to another of different density. The amount that the light bends depends on refractive index of each substance along with the shape. The eye focuses images on the retina, and our eyes are built for viewing in air. Water has approximately the same refractive index as the cornea which effectively eliminates the cornea's focusing properties. This is why you see a blurred image underwater. The eyes are focusing the image far behind the retina instead of on the retina. The waterscope puts a layer of air between your eyes and the water (the same way goggles do) so you can view underwater without blurred vision.

Lesson

1. Ask students if it would be better to go look at a fish underwater in a lake or the ocean (with the naked eye), or if it would be better to look at the fish in an aquarium.
2. If they say "aquarium" ask why. Say: *That's right! An aquarium will allow us to see the animals clearly, while underwater is muddy and blurry at best.*
3. Say: *We can't see well underwater because our eyes are adapted for viewing in air. When underwater, the water has the same refractive index as the cornea, which eliminates the cornea's focusing ability under water. So, everything looks blurry.*

4. Explain: *Today we are going to build a layer to put between our eyes and the water, which will help focus everything underwater, just like the glass of an aquarium does.. Our layer is a plastic wrap!! The plastic will function like goggles!*

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. Clean out your jug first. Then cut the bottom and top off without cutting off the handle.
4. Cover the opening at the bottom with your plastic wrap, securing it in place with the rubber band. Use tape if you need extra support to hold the plastic wrap in place. The window needs to be water-tight.
5. Place the waterscope in the water, bottom-side down. You'll be able to see all kinds of interesting creatures through your scope!
6. Try to keep your scope still so the animals won't be afraid to come close to you so you can have a good peek at their world. The aquascope works the same way snorkel goggles work—except you don't have to get wet!
7. The key to the aquascope is the taught plastic wrap. If it's loose, or if there are holes, it won't work as well. Make sure that the plastic wrap is securely fastened to the can, and is stretched tight. If you find your waterscope leaks, use a stronger rubber band to secure your plastic wrap in place. You can alternatively use strong waterproof tape or hot glue to secure it in place, but use the rubber band first so you can stretch the film tightly over the open end.

Exercises

1. What is the term for light rays bending? (refraction)
2. Why is underwater vision blurred? (Because water has the same refractive index as the cornea, which effectively eliminates the cornea's focusing property.)
3. How can we focus vision underwater? (Put a layer of something with a different refractive index between your eye and the water. Plastic or air are good examples of this.)

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: Waterscope

Student Worksheet

Name____

Overview Tide pools are best observed undisturbed. But, they're too shallow to snorkel… So how to can we explore them without removing their inhabitants? With an Aquascope! Aquascopes are very cheap and easy to make. With only a coffee can, some plastic food rap, and a couple of other items you can make a window into the world of tide-pools! In principle, aquascopes allow us to take a glass-bottom-boat tour of the rich ecosystems of tide pools. The plastic acts as the glass, while the coffee can allows us to break the distorting surface of the water.

What to Learn You can't see clearly underwater with just your eyes for a couple of reasons. One is the thickness of the lens on your eye, but the main one is the index of refraction of water is different than that of air. Light rays bend when they travel from one medium to another of different density (refer to the Disappearing Beaker experiment for more on this topic). The amount that the light bends depends on refractive index of each substance along with the shape. The eye focuses images on the retina, and our eyes are built for viewing in air. Water has approximately the same refractive index as the cornea which effectively eliminating the cornea's focusing properties. This is why you see a blurred image underwater. The eyes are focusing the image them far behind the retina instead of on the retina. The waterscope puts a layer of air between your eyes and the water (the same way goggles do) so you can view underwater without blurred vision.

Materials

- milk or juice jug
- plastic wrap
- scissors
- rubber band

Lab Time

1. Clean out your jug first. Then cut the bottom and top off without cutting off the handle.
2. Cover the opening at the bottom with your plastic wrap, securing it in place with the rubber band. Use tape if you need extra support to hold the plastic wrap in place. The window needs to be water-tight.
3. Place the waterscope in the water, bottom-side down. You'll be able to see all kinds of interesting creatures through your scope!
4. Try to keep your scope still so the animals won't be afraid to come close to you so you can have a good peek at their world. The aquascope works the same way snorkel goggles work—except you don't have to get wet!
5. The key to the aquascope is the taught plastic wrap. If it's loose, or if there are holes, it won't work as well. Make sure that the plastic wrap is securely fastened to the can, and is stretched tight. If you find your waterscope leaks, use a stronger rubber band to secure your plastic wrap in place. You can alternatively use strong waterproof tape or hot glue to secure it in place, but use the rubber band first so you can stretch the film tightly over the open end.
6. Draw what you see through your waterscope in the circles below and label each drawing:

Exercises Answer the questions below:

1. What is the term for light rays bending?

2. Why is underwater vision blurred?

3. How can we focus vision underwater?

Lesson #22: Protozoa in the Grass

Teacher Section

Overview What makes things alive? There are actually many hints that tell us something is alive. One thing that is true about all living things is that they all have tiny structures called cells. Cells are the smallest objects that can do all the things needed for life. Some people call cells the “building blocks” of life. Cells get put together to make apple trees, elephants, or whatever other living thing you can imagine!

This experiment allows you to see protozoa, tiny single-celled organisms, in your compound microscope. While some people can go in their backyard and find a lot of interesting pond scum and dead insects, not everybody has a thriving ecosystem on hand, especially if they live in a city. In this activity, you will learn how to grow a protozoa habitat that you can keep in a window for months (or longer!) using a couple of simple ingredients.

Suggested Time 30-45 minutes

Objectives : Students will grow protozoa, tiny single-celled organisms and observe protozoa through a microscope. As multicellular organisms develop, their cells differentiate.

Materials (per lab group)

- a glass jar with a lid
- a spoon
- yeast
- dead grass
- water
- an eye dropper
- cover slips
- microscope slide
- a compound microscope

Lab Preparation

1. Helpful hints for the teacher:
    - You don’t have to throw the mixture away at the end of the lab. Keep it and have students take another slide a week or two later.
    - Students may need to review the section on wet mount slides.
    - Using a compound microscope yields best results. See the section on microscopes for more information on suggested models.
2. Print out copies of the student worksheets.
3. Read over the Background Lesson Reading before teaching this class.
4. Watch the video for this experiment to prepare for teaching this class.

Background Lesson Reading

Every living thing, from tiny bacteria to giant oak trees, began life as a single cell. So how do living things go from one cell to the trillions of cells some living things are made of? The answer is cell division! **Cell division** is a process in which one cell becomes two cells. The cell that starts cell division is called the **parent cell** and the cells that the parent cell makes are called **daughter cells** (even though cells are not male or female.)

There are several different kinds of cell division that we will talk about.

Binary Fission: One simple form of cell division is binary fission. This process has three steps. In the first step, the DNA doubles, so that the daughter cells will each have all of the DNA fount in the parent cell. Next, the two sets of DNA move to the sides of the cell. Finally, a new cell membrane begins to grow in the middle of the parent cell. Eventually the cell breaks apart, and, just like that, daughter cells have formed.

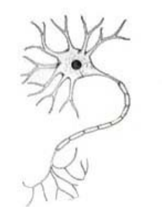
Budding: In this yeast cell, the bud is visible at the top of the cell. Another method of cell division is called budding. In this method, a small "bud" forms on the parent cell. The bud looks kind of like a bubble sticking out of part of the cell. Eventually, the bud develops all the material it needs and breaks off, forming a daughter cell. In the yeast cell above, the bud is visible at the top of the cell.

Protozoa are tiny single-celled organisms called protists with animal-like behaviors. Protists live in almost any liquid water environment. Some protists are vital to the ecosystem while others are deadly.

Once you have a protist farm is up and running, you'll be able to view a sample with your compound microscope. If you don't know how to prepare a wet mount or a heat fix, you'll want to review the microscope lessons.

Lesson

1. Ask students: "*What are Legos? What do we do with Legos?*"
2. Explain: "*That's right. Basically, we put Legos together to build things*."
3. Ask: "*Are all Legos the same?*"
4. Explain: "*That's right. Legos are different shapes and sizes, because we need different types to build different parts of a structure. Cells are just like Legos—they all come in different shapes and sizes to do different jobs. Many cells have special shapes that help them do their job well. For example, one group of cells, called nerve cells, have the job of getting messages to other cells. Nerve cells have long extensions coming out of them so they can easily reach the cells they need to give the message to.*"
5. Show an example of a nerve cell.



6. Explain: *Although cells may have different shapes, they are all very small. In fact, you could fit about 500 average-sized cells in the period at the end of this sentence. Being small is good for cells, because it allows materials to get in and out of the cells very quickly. Cells take in nutrients, which are substances that are helpful to people or other living things, and get rid of waste. If it took a long time for the good stuff to get in or the bad stuff to get out, the cell could not survive.*
7. Explain: *In this activity, we will grow and examine a tiny, single-celled organism called a protozoa. It is a protest with animal like behavior.*

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. Leave a glass of water out overnight, to get rid of chlorine. If you are in a hurry, use filtered water (not distilled) instead.
4. Add dead grass to the glass of water. Stir.
5. Add yeast to the glass. Stir again.
6. Allow the glass to sit overnight in a warm place. For best results, let grow and ferment for several weeks.
7. Each day for a week, observe a sample of water and/or grass under the microscope, after the first 24 hours.
8. Sketch the protozoa you see, and note if there are more or less of a certain type as time goes on in your science journal.

Exercises

1. What is a cell? (A cell is a tiny structure that is the "building block" of life. It is the smallest object that can do all the things needed for life.)
2. Why are cells so small? (To get nutrients in and waste out efficiently. Otherwise they would starve or poison themselves.)
3. What is a protozoa? (A tiny, single-celled organism. It is a protist with animal like behavior.)
4. How does it develop? (It develops in grass, yeast and water.)

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: Protozoa in the Grass

Student Worksheet

Name____

Overview What makes things alive? There are actually many hints that tell us something is alive. One thing that is true about all living things is that they all have tiny structures called cells. Cells are the smallest objects that can do all the things needed for life. Some people call cells the "building blocks" of life. Cells get put together to make apple trees, elephants, or whatever other living thing you can imagine!

What to Learn This experiment allows you to see protozoa, tiny single-celled organisms, in your compound microscope. Protozoa have different shapes, so you will examine samples of your protist farm every few days, to see what different shapes occur.

While some people can go in their backyard and find a lot of interesting pond scum and dead insects, not everybody has a thriving ecosystem on hand, especially if they live in a city. In this activity, you will learn how to grow a protozoa habitat that you can keep in a window for months (or longer!) using a couple of simple ingredients.

Materials

- a glass jar with a lid
- a spoon
- yeast
- dead grass
- water
- an eye dropper
- cover slips
- microscope slide
- a compound microscope

Lab Time

1. Leave a glass of water out overnight, to get rid of chlorine. If you are in a hurry, use filtered water (not distilled) instead.
2. Add dead grass to the glass of water. Stir.
3. Add yeast to the glass. Stir again.
4. Allow the glass to sit overnight in a warm place. For best results, let grow and ferment for several weeks.
5. Each day for a week, observe a sample of water and/or grass under the microscope, after the first 24 hours.
6. Sketch the protozoa you see, and note if there are more or less of a certain type as time goes on in your science journal.
7. Draw what you see under the microscope in the circles below. Be sure to title each drawing and label it with the magnification power level.

Exercises Answer the questions below:

1. What is a cell?

2. Why are cells so small?

3. What is a protozoa?

4. How does it develop?

Lesson #23: Extracting DNA in Your Kitchen

Teacher Section

Overview DNA is the genetic material that has all the information about a cell. If the cell has a nucleus, the DNA is located in the nucleus. If not, it is found in the cytoplasm. DNA is a long molecule found in the formed by of two strands of genes. DNA carries two copies—two "alleles"—of each gene. Those alleles can either be similar to each other (homozygous), or dissimilar (heterozygous). We're going to learn how to extract DNA from any fruit or vegetable you have lying around the fridge.

Suggested Time 30-45 minutes

Objectives : Students will extract DNA from vegetable or fruit matter, identify DNA, and examine the DNA under the microscope. Many characteristics of an organism are inherited from the parents. Some characteristics are caused by, or influenced by, the environment. DNA is the genetic material of living organisms, and is located in the chromosomes of each cell. Living organisms have many different kinds of molecules including small ones such as water and salt, and very large ones such as carbohydrates, fats, proteins and DNA.

Materials (per lab group)

- pumpkin OR apple OR squash OR bananas OR carrots OR anything else you might have in the fridge
- dishwashing detergent
- 91% isopropyl alcohol
- coffee filter and a funnel (or use paper towels folded into quarters)
- water
- blender
- clear glass cup

Lab Preparation

2. Helpful hints for the teacher:
   - Make sure students don't over blend the fruit or veggie, or they will destroy the DNA strands.
   - If paper towels are too large for the funnel, you may want to cut them to fit ahead of time. If not, students can cut them during the experiment.
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

DNA (short for deoxyribonucleic acid), the double-helix shaped molecule found in all cells, answered the question of what these "inheritance factors" were. DNA is often thought of as the cell's "recipe book." DNA holds the instructions for building proteins the same way recipe books hold the instructions for making dishes.

Veggies and fruits are made of water, cellulose, sugars, proteins, salts, and DNA. To get at the DNA, you first need to get inside the cells and separate it out from the other parts. The blender breaks up the fibers that hold the cells together.

The salt and detergent are added next so they can break down the cell walls. Cell walls of plants are made of cellulose. Inside that cellulose is another cell wall (cell membrane). This membrane has an outer later of sugar and an inner layer of fat.

The detergent is a special molecule that has an attraction to water and fats (which is why it works to get your dishes clean). The end of the molecule that is attracted to fat attaches to the fat part of the cell membrane. When you stir up the mixture, it breaks up the membrane (since the other end likes water). It wedges itself inside and opens the cell up… which causes the DNA to flow out.

Since DNA dissolves in water, it stays in the vegetable juice. When alcohol is added, the DNA "comes out" of solution as the ghostly white strands seen at the bottom of the alcohol layer.

Lesson

1. Hold up a carrot and ask students: "What is this made of?"
2. As students give answers, or if they get stuck, direct them by asking, "Do you think there is water in here? Fat?" etc until you name the "ingredients" of a carrot: water, cellulose, sugars, proteins, salts, and DNA.
3. Explain that fruit and vegetables are made of water, cellulose, sugars, proteins, salts, and DNA. Today we are going to take a closer look at these elements of a carrot, especially DNA.
4. Ask your students: What can we do In order to see what something is made of? (examine it closely, take it apart)
5. Explain in this activity, we are going to take the carrot apart, by separating the parts listed. Then we are going to examine the DNA strands under a microscope.
6. Explain that DNA is a long molecule, which spirals like a staircase.
7. DNA carries the "recipes" of a cell. These "recipes" are for making a protein. These recipes, in scientific terms, are called genes. So, DNA carries genes. The genes are how traits are copied from one generation to the next.
8. To take the carrot apart, we are first going to break the fibers. We will do this with the blender.
9. Then, to further break down the carrot, we will use detergent to pull open the cells, so the DNA can flow out of the cell. Detergent has a special molecule to break open the cells. On one end, this molecule pulls on (or is attracted to fat), and on the other end, it is attracted to water. By pulling the cell membrane apart in this way, detergent molecules can get inside, and "hold the door open," so the DNA strands can flow out.
10. DNA dissolves in water (here, the carrot juice). Finally, the alcohol pulls the DNA out of the juice, so we can see it under the microscope.

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, grab your fruit or vegetable and stick it in your blender with enough water to cover. Add a tablespoon of salt and blend until it looks well-mixed and like applesauce. Don't over-blend, or you'll also shred the DNA strands!

4. Pour this into a bowl and mix in the detergent. Don't add this in your mixer and blend or you'll get a foamy surprise that's a big mess. You'll find that the dishwashing detergent and the salt help the process of breaking down the cell walls and dissolving the cell membranes so you can get at the DNA.
5. Place a coffee filter cone into a funnel (or use a paper towel folded into quarters) and place this over a cup. Filter the mixture into the cup. When you're done, simply throw away the coffee filter. Note: Keep the contents in the cup!
   Step 4: *Be careful with this step!* You'll very gently (no splashing!) pour a very small about of alcohol into the cup (like a tablespoon) so that the alcohol forms a layer above the puree.
6. Observe! Grab your compound microscope and take a sample from the top. You'll want a piece from the ghostly layer between the puree and the alcohol – this is your DNA.

Exercises

- What are fruits and veggies made of? (water, cellulose, sugars, proteins, salts, and DNA.)
- What does DNA stand for? (deoxyribonucleic acid)
- What is DNA? (DNA is often thought of as the cell's "recipe book." DNA holds the instructions for building proteins the same way recipe books hold the instructions for making dishes.)
- What is a gene? (Genes are individual codes for making proteins that are passed on from generation to generation.)
- Describe the structure of DNA. (It is a double-helix shaped molecule found in all cells. It is in the form of a long double strand, like a spiral staircase.)

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: Extracting DNA in Your Kitchen

Student Worksheet

Name____

Overview DNA (short for deoxyribonucleic acid), the double-helix shaped molecule found in all cells, answered the question of what these "inheritance factors" were. DNA is often thought of as the cell's "recipe book." DNA holds the instructions for building proteins the same way recipe books hold the instructions for making dishes. Veggies and fruits are made of water, cellulose, sugars, proteins, salts, and DNA. In this activity, you will use a blender and dish soap to extract DNA from fruits and veggies.

What to Learn DNA is the genetic material that has all the information about a cell. If the cell has a nucleus, the DNA is located in the nucleus. If not, it is found in the cytoplasm. DNA is a long molecule found in the formed by of two strands of genes. DNA carries two copies—two "alleles"—of each gene. Those alleles can either be similar to each other (homozygous), or dissimilar (heterozygous). In this activity, you will learn how to extract DNA from any fruit or vegetable you have lying around the fridge.

Materials

- pumpkin OR apple OR squash OR bananas OR carrots OR anything else you might have in the fridge
- dishwashing detergent
- 91% isopropyl alcohol
- coffee filter and a funnel (or use paper towels folded into quarters)
- water
- blender
- clear glass cup

Lab Time

Here's how you make it:

7. First, grab your fruit or vegetable and stick it in your blender with enough water to cover. Add a tablespoon of salt and blend until it looks well-mixed and like applesauce. Don't over-blend, or you'll also shred the DNA strands!
8. Pour this into a bowl and mix in the detergent. Don't add this in your mixer and blend or you'll get a foamy surprise that's a big mess. You'll find that the dishwashing detergent and the salt help the process of breaking down the cell walls and dissolving the cell membranes so you can get at the DNA.
9. Place a coffee filter cone into a funnel (or use a paper towel folded into quarters) and place this over a cup. Filter the mixture into the cup. When you're done, simply throw away the coffee filter. Note: Keep the contents in the cup!
   Step 4: *Be careful with this step!* You'll very gently (no splashing!) pour a very small about of alcohol into the cup (like a tablespoon) so that the alcohol forms a layer above the puree.
10. Observe! Grab your compound microscope and take a sample from the top. You'll want a piece from the ghostly layer between the puree and the alcohol – this is your DNA.

Extracting DNA in Your Kitchen Data Table

Fruit or Veggie	Draw a Picture of the DNA Under the Microscope

Exercises Answer the questions below:

1. What are fruits and veggies made of?

2. What does DNA stand for?

3. What is DNA?

4. What is a gene?

5. Describe the structure of DNA.

Lesson #24: Tracking Traits

Teacher Section

Overview Why do families share similar features like eye and hair color? Why aren't they exact clones of each other? These questions and many more will be answered as well look into the fascinating world of genetics!

Genetics asks which features are passed on from generation to generation in living things. It also tries to explain how those features are passed on (or not passed on). Which features are stay and leave depend on the genes of the organism and the environment the organism lives in. Genes are the "inheritance factors "described in Mendel's laws. The genes are passed on from generation to generation and instruct the cell how to make proteins. A genotype refers to the genetic make-up of a trait, while phenotype refers to the physical manifestation of the trait.

Suggested Time 30-45 minutes

Objectives Many characteristics of an organism are inherited from the parents. An inherited trait can be determined by one or more genes. Students will define the terms "dominant" and "recessive" related to genetic traits, and use a Punnet square to determine possible genetic traits of offspring.

Materials (per lab group)

- Paper and Genetics Table
- Crayons or markers
- Two different coins
- Coin (like a penny)

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

Mendel developed **the law of segregation**—a law that still serves as a fundamental law of modern genetics. The law states that each organism gets two copies of the same gene, which separate (the "segregation" in the name of the law) when gametes are produced.

Mendel used this law to resolve the curious results found in the short pea plant/tall pea plant experiment. He guessed that each plant has two copies of the same trait, but could only pass on one copy through reproduction. He then guessed that some traits were more dominant—more likely to show itself in the offspring—than others. For example, the *tall* trait was more dominant than the *short* trait. He called these traits that were more likely to be chosen (like the tall trait) **dominant**, and the traits less likely to be chosen (like the short trait) **recessive**.

His experiments showed that if a plant with a dominant trait and a plant with a recessive trait reproduced the F1 generation would be 100% dominant trait. For example, all of the offspring of the tall and short plant were tall. But, the F2 would always be 75% dominant and 25% recessive—and F2 generation that was 75% tall and 25% short, in our example.

The dominant traits are designated by a capital letter, and the recessive traits are designated by a lowercase letter. For example, the dominant trait "tall" is designated the letter *T*, while short is given the lowercase letter *t*. Since the plants have two copies of each trait the combinations can be either TT, Tt, tT, or tt.

If both copies are dominant, than the dominant trait is seen (TT= tall plant). If there's a mix, than the dominant trait is seen (Tt/tT = tall plant). If both traits are recessive, than the recessive trait is seen (tt = short plant). Since three of the four options result in tall plants, and one of the four results in short plants, it makes sense that Mendel observed the results he did.

That's because after the first generation of TT X tt all of the plants were Tt and tT. But, when the tT/Tt generation was crossed, the plants could have all four combinations. Three out of the four combinations (TT, tT, and Tt) yield dominant traits, while the fourth combination (tt) yields short plants. Thus ¾ = 75%, and ¼ = 25%.

A good way of visualizing these results is with **Punnett Squares**. Punnett squares are simply tables we can use to show the possible combinations of traits. In our Tall/short example we can draw this Punnett Square:

Parental (P) Generation: TT crossed with tt

	The Recessive Plant		
The Dominant Plant		**t**	**t**
	T	Tt	Tt
	T	Tt	Tt

Result: 100% Tt. 100% tall.

F1 Generation: Tt crossed with Tt

	T	**t**
T	TT	Tt
t	tT	tt

Result: 25% TT, 50% Tt, 25% tt. 75% tall, 25% short.

Genotype and Phenotype Genotype and phenotype are the words we use to describe what genes an organism has, and which traits are expressed, respectively. They are extremely useful because organisms do not express all of their genes—mostly the dominant ones. We use the word "genotype" to describe the genetic composition of a cell. Is the cell a TT? Is it a Tt? Is it a tt? To talk about which genes an organism has we use the word "genotype".

Phenotype, on the other hand, is just used to describe the appearance of the organism. Is it round? Wrinkled? Tall? Short? The phenotype is the physical trait expressed.

Lesson

1. Ask students to think of a physical feature that they share with one or both of their biological parents OR they can think of a famous family that has a shared trait. Let a few students share out.
2. Tell students one feature about you and your parents or offspring. Eye color or hair color can be good examples. For example, "*My mother and I have black hair.*" Or you can discuss a trait that you do not have. For example, "My mother and I do not have freckles."
3. Explain: *These traits are called genetic traits, because they are determined by our genes. We get our genes from our parents; we get one half from our mother and one half from our father.*
4. Draw a fictitious family on the board: a mother with blue eyes and black hair, a father with brown eyes and blond hair a child with no eyes and no hair. Ask: *What color eyes do you think the child will have?*
5. Explain: *The child will either have blue eyes or brown eyes. It will not have a mixture of those two colors.*
6. Check understanding: *So, if in the same family, the mother has black hair (draw them) and the father has blond hair, what are the possibilities for the child?* Tell a partner. *The child can either have black hair or blond hair.*
7. Explain: *The way we represent these traits is with two letters that represent genes. One letter comes from the mother, and one from the father. Each trait is either dominant or recessive. So, if the mother has black hair, one of her two hair genes is for black hair. Let's label that as capital B. (B for black and capital because black hair is a dominant trait.) We are going to give this mother a small b for her second hair gene, because we are going to assume that one of her parents passed a recessive hair color gene down to her.*
8. Explain: *Since the father has blond hair, he must have two recessive genes (because otherwise the dominant trait would have appeared.) So his hair color genes are represented as bb*.
9. Explain: *So, for this family, for the trait of hair color, we have Bb crossed with bb.*
10. Check understanding: *What would we have for eye color, assuming brown is represented by B and blue by b? What two eye color genes would the mother have, and what would the father have? The mother has blue eyes, so her eye color gene would necessarily be bb, and the father would have to have at least one B. The other could be either B or b, let's just pick b.*
11. Explain: *So in this family, we cross bb with Bb for eye color.*
12. Now there is one final step to figure out the possibilities for the child's genes. For hair color, we have BB x bb. There are always four possibilities when crossing genes. Draw a Punnet square on the board. Demonstrate crossing.
13. Have students do the same for eye color in this example, Bb x bb.
14. Explain: You are going to determine offspring gene traits and then draw them.

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're going to create the genetic make-up of the parents. Here's how:
4. Take out the Genetics Data Table, and flip the first coin to create the genetic profile for the mother.
5. Flip the coin and in the Mother's Hair trait column, write **D for dominant** if the coin reads heads, and **R for recessive if tails** in the table.
6. Flip the coin again. In the Mother's Hair trait column right after the first trait, write **D for dominant** if the coin reads heads, and **R for recessive if tails** in the table.
7. If you flipped heads the first time and tails the second, you'd write "DR" in the Mother's Hair box.

8. Continue this process for all of Mother's traits. You should have two letters in each box for the entire column.
9. Repeat these steps for Father. When you've completely filled out Mother's and Father's columns, you've completed the paternal genetic profile.
10. Will the child be a boy or a girl? To determine this, flip the second coin. **Heads for a boy, tails for a girl.** After this is decided, circle *boy* or *girl* under "child 1" on the Genetics Data Table.
11. Now the first coin will represent the gene from the mother and the second coin will represent the gene from the father.
12. Start with the Hair trait: Flip both coins. **If the first coin is tails, take the first trait from the mother. If the first coin is heads, take the second trait**.
13. For example, if the first coin is tails, and the mother's code is DR, then write "D" in the child one column for hair.
14. Do the same thing for the father's traits with the second coin. For example, if the second coin is heads, and the father's code is DR, then write "R" in the Hair Trait column of child 1.
15. By the end of this step, child 1 should have one letter from the mother, and one letter for the father in child 1's hair trait column.
16. Use the same steps used to find the genetic code for the hair trait to find the code for the rest of the traits. By the end all the traits should have one letter from the mother's genetic code and one letter from the father's genetic code.
17. Grab a sheet of paper and start drawing the child. If the genetic code for a trait has a "D" in it, then the dominant trait is used.
18. For example, if the hair color is DD, DR, or RD then the hair color is dark. If the hair color code is RR, then hair color is light. Draw the traits on your paper! You can repeat this for as many children as you would like in your family.
19. Are all families alike? What if you try this process again for another family? Do you see any similarities or differences? Do similar features come from dominant genes? Do differences come from recessive genes? What other traits would you include? Write this in your science journal!

Exercises

1. What is the difference between a genotype and a phenotype? (Genotype describes the genetic makeup of the cell: Bb for example. Phenotype describes the appearance that the trait causes: Black hair, for example.)
2. What is a dominant trait? (The trait that is more likely to show up)
3. What is a recessive trait? (The trait that is less likely to show up)
4. Assume B=Black hair and b=blond hair. Make a Punnett square to cross Bb with bb. Tell each possible hair color of the offspring.

	B	b
b	Bb	bb
b	Bb	bb

5. Why don't traits simply average out in offspring. For example, why does a tall plant crossed with a short plant not yield a bunch of average-sized plants?(Because discreet genes are passed down, and then the dominant trait or recessive trait appears. They do not mix. The plants will either be tall or short.)
6. In your activity, what percent of the children expressed the dominant allele of each trait? Did you get Mendel's results? Do the calculations and check it 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.

Lesson #24: Tracking Traits

Student Worksheet

Name____

Overview Why do families share similar features like eye and hair color? Why aren't they exact clones of each other? These questions and many more will be answered as well look into the fascinating world of genetics!

What to Learn Genetics asks which features are passed on from generation to generation in living things. It also tries to explain how those features are passed on (or not passed on). Which features are stay and leave depend on the genes of the organism and the environment the organism lives in. Genes are the "inheritance factors "described in Mendel's laws. The genes are passed on from generation to generation and instruct the cell how to make proteins. A genotype refers to the genetic make-up of a trait, while phenotype refers to the physical manifestation of the trait. In fact, most similarities should come from the dominant genes because they are expressed more often. The recessive genes are expressed less often, so they create the differences.

Materials

- Paper and Genetics Table
- Crayons or markers
- Two different coins
- Coin (like a penny)

Lab Time

1. First you're going to create the genetic make-up of the parents. Here's how:
2. Take out the Genetics Data Table, and flip the first coin to create the genetic profile for the mother.
3. Flip the coin and in the Mother's Hair trait column, write **D for dominant** if the coin reads heads, and **R for recessive if tails** in the table.
4. Flip the coin again. In the Mother's Hair trait column right after the first trait, write **D for dominant** if the coin reads heads, and **R for recessive if tails** in the table.
5. If you flipped heads the first time and tails the second, you'd write "DR" in the Mother's Hair box.
6. Continue this process for all of Mother's traits. You should have two letters in each box for the entire column.
7. Repeat these steps for Father. When you've completely filled out Mother's and Father's columns, you've completed the paternal genetic profile.
8. Will the child be a boy or a girl? To determine this, flip the second coin. **Heads for a boy, tails for a girl.** After this is decided, circle *boy* or *girl* under "child 1" on the Genetics Data Table.
9. Now the first coin will represent the gene from the mother and the second coin will represent the gene from the father.
10. Start with the Hair trait: Flip both coins. **If the first coin is tails, take the first trait from the mother. If the first coin is heads, take the second trait**.
11. For example, if the first coin is tails, and the mother's code is DR, then write "D" in the child one column for hair.

12. Do the same thing for the father's traits with the second coin. For example, if the second coin is heads, and the father's code is DR, then write "R" in the Hair Trait column of child 1.
13. By the end of this step, child 1 should have one letter from the mother, and one letter for the father in child 1's hair trait column.
14. Use the same steps used to find the genetic code for the hair trait to find the code for the rest of the traits. By the end all the traits should have one letter from the mother's genetic code and one letter from the father's genetic code.
15. Grab a sheet of paper and start drawing the child. If the genetic code for a trait has a "D" in it, then the dominant trait is used.
16. For example, if the hair color is DD, DR, or RD then the hair color is dark. If the hair color code is RR, then hair color is light. Draw the traits on your paper! You can repeat this for as many children as you would like in your family.
17. Are all families alike? What if you try this process again for another family? Do you see any similarities or differences? Do similar features come from dominant genes? Do differences come from recessive genes? What other traits would you include? Write this in your science journal!

Tracking Traits Data Table

Trait or Feature	Dominant	Recessive	Mother	Father	Child 1 Boy or Girl?	Child 2 Boy or Girl?	Child 3 Boy or Girl?
Hair	*Dark Hair Color (black or dark brown)*	*Light Hair Color (red or blonde)*					
Eyes	*Brown/Hazel/Green*	*Blue/Grey*					
Eye Placement	*Close*	*Far*					
Eyebrows	*Bushy*	*Thin*					
Mouth Size	*Long*	*Average*					
Nose	*Pointed*	*Rounded*					
Freckles	*Yes*	*No*					

There are many genetic traits. Can you make up a table of your own in your science journal?

Draw the family:

Exercises Answer the questions below:

1. What is the difference between a genotype and a phenotype?

2. What is a dominant trait?

3. What is a recessive trait?

4. Assume B=Black hair and b=blond hair. Make a Punnet square to cross Bb with bb. Tell what the possibilities are for offspring hair color.

5. Why don't traits simply average out in offspring. For example, why does a tall plant crossed with a short plant not yield a bunch of average-sized plants?

6. In your activity, what percent of the children expressed the dominant allele of each trait? Did you get Mendel's results? Do the calculations and check it out!

Life Science 1 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 Life Science:

1. Animals eat plants or other animals for food and may also use plants or even other animals for shelter and nesting.
2. The germination, growth, and development of plants can be affected by light, gravity, touch, or environmental stress.
3. Plants and animals have structures that serve different functions in growth, survival, and reproduction.
4. When the environment changes, some plants and animals survive and reproduce, and others die or move to new locations.
5. Plants use carbon dioxide and energy from sunlight to build molecules of sugar and release oxygen.
6. Plant and animal cells contain many thousands of different genes, and typically have two copies of every gene. The two copies (or alleles) of the gene may or may not be identical, and one may be dominant in determining the phenotype while the other is recessive.
7. Proper recording of data viewed through a microscope.

Students will also demonstrate these principles:

1. Proper mounting of slides for viewing with a microscope.
2. Roots are associated with the intake of water and soil nutrients, green leaves with making food from sunlight.
3. Cells function similarly in all living organisms.
4. Many characteristics of an organism are inherited from the parents. Some characteristics are caused by, or influenced by, the environment.
5. An inherited trait can be determine by one or more genes.

Materials (one set for entire class)

- microscope
- slides
- cover slips
- 1 dry mount specimen, such as a thread
- 1 bumpy dry mount specimen, such as a coin
- 1 wet mount specimen, such as pond water
- tweezers
- an eye dropper
- paper towels
- 2 carrots
- 2 clear cups or glasses
- a bottle of water

- salt
- 2 strings
- 1 index card with Bb written on it
- 1 index card with bb written on it

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 mount slides for viewing with a microscope, demonstrate an understanding of the process of osmosis, and simulate inheritance of genetic traits. 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.

Homework Assignment

Design a garden and label its parts. Your drawing must include: plants, insects, decomposers, as well as water, light and nutrients. Use arrows to show the transfer of energy. You must also include a detailed written description of at least one page, explaining the science that is happening in the garden.

Life Science 1 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 life science 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 get started on your homework assignment. The assignment is due next week, 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.

   Here it is: Design a garden and label its parts. Your drawing must include: plants, insects, decomposers, as well as water, light and nutrients. Use arrows to show the transfer of energy. You must also include a detailed written description of at least one page, explaining the science that is happening in the garden.

Life Science 1 Quiz

Teacher's Answer Key

1. Fill out the table to figure out how to set the lenses for the different magnification powers:

Eyepiece	Objective	Total Magnification
10X	*4x*	40x
10x	10x	100X
10x	40X	*400x*

2. Match the name of the slide mount that would best fit the following specimens:

dry mount stain heat fix

10. cheek cells *heat fix*
11. a strand of hair *dry mount*
12. an thin piece of onion *stain*

3. Describe the function of each plant part below:

- Root: *takes in water and nutrients.*
- Stem*: transports water and nutrients.*
- Leaf: *allows for photosynthesis and transpiration. (takes in sunlight and lets out water!)*
- Flower: *attracts animals to help plants reproduce.*

4. Name and describe the process of how water gets into a celery stalk. (*Water enters a plant through a passive transport process called osmosis. It travels through the xylem, from most concentrated to least concentrated area. The concentration of water is greater outside of the stalk, so water travels into the stalk to the area of least concentration of water.*)

5. In what direction does water travel? (*It travels from the area of most concentration to the areas of least concentration.)*

6. What happens if you add salt to a water cycle column?

7. Would a boat float better in honey or fresh water? Explain. (*A boat would float better in honey. Liquid can get stronger as it gains density. Since honey is denser than fresh water, it would push harder on the boat. Therefore the boat would raise up higher in the honey.)*

8. Name three types of worms and give the characteristics of each. *(Flat worms, round worms, and segmented worms. Flat worms have an incomplete digestive system and no body cavity; round worms have a body cavity and a complete digestive system; and segmented worms have a body cavity and repeating segments)*

9. Why are worms important to gardens? Give at least two reasons. (*Answers may vary. They should include two of the following reasons: Worms churn the soil; they decompose plant matter into fertilizer; and they dig tunnels allow roots to plant themselves more easily.)*

10. Why is a heterotroph called a "carnivorous" plant? (*Heterotroph means that an organism must eat other organisms to get its energy, instead of getting its energy from the sun. Carnivorous plants eat small animals, such as insects.)*

11. Write the equation for photosynthesis. ($6CO_2 + 6H_2O + \text{Light Energy} \rightarrow C_6H_{12}O_6 + 6O_2$)

12. Describe in words the process of photosynthesis. (*Carbon dioxide, water, and light energy combine to form glucose and oxygen.)*

13. Name and briefly describe the four stages of mitosis. (*Stage 1: Prophase—nuclear structure breaks down and DNA forms chromosomes; Stage 2: Metaphase—chromosomes line up along center of the parent cell; Stage 3: Anaphase —chromosomes break apart with a complete set of DNA going to each side of the cell; Stage 4: Telophase—a new nuclear membrane forms around each new set of DNA)*

14. What are two tools that a student can build to catch tiny or hard to see insects? Briefly describe how each tool works. *(The Insect Aspirator and the Berlese Funnel. The insect aspirator uses a vacuum principle, where one creates suction by sucking through a straw in an empty water bottle. Insects are "vacuumed up" through a second straw that goes into the same bottle. The Berlese Funnel heats soil, making it too hot for the insects. The insects then move through the funnel to the bottom, cooler chamber.)*

15. How does a waterscope work? *(The waterscope puts a layer of air between your eyes and the water (the same way goggles do) so you can view underwater without blurred vision)*

Life Science 1 Quiz

Name____

1. Fill out the table to figure out how to set the lenses for the different magnification powers:

Eyepiece	Objective	Total Magnification
10X		40x
	10x	100X
10x	40X	

2. Match the name of the slide mount that would best fit the following specimens:

   dry mount   stain   heat fix

   a. cheek cells ________________
   b. a strand of hair ________________
   c. an thin piece of onion ______________

3. Describe the function of each plant part below:

   - Root:
   - Stem:
   - Leaf:
   - Flower:

4. Name and describe the process of how water gets into a celery stalk.

5. In what direction does water travel?

6. What happens if you add salt to a water cycle column?

7. Would a boat float better in honey or water? Explain.

8. Name three types of worms and give the characteristics of each.

9. Why are worms important to gardens? Give at least two reasons.

10. Why is a heterotroph called a “carnivorous” plant?

11. Write the equation for photosynthesis.

12. Describe in words the process of photosynthesis.

13. Name and briefly describe the four stages of mitosis.

14. What are two tools that a student can build to catch tiny or hard to see insects? Briefly describe how each tool works.

15. How does a waterscope work?

Life Science 1 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:

- microscope
- slides
- cover slips
- 1 dry mount specimen, such as a thread
- 1 bumpy dry mount specimen, such as a coin
- 1 wet mount specimen, such as pond water
- tweezers
- an eye dropper
- paper towels
- 2 carrots
- 2 clear cups or glasses
- a bottle of water
- salt
- 2 strings
- 1 index card with Bb written on it
- 1 index card with bb written on it

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

- Demonstrate the proper way to mount a copper penny. *(Student should put the penny on a slide with no cover slip, then clip the slide on the base. Student should then look at base while adjusting coarse adjustment knob, then look through eye piece while doing fine adjustment.)*
- Demonstrate the proper way to mount pond water. *(Student should use eye dropper to put one drop of pond water on a slide. Student should then use tweezers to put a cover slip on one end of the drop, then carefully lower the cover slip onto the whole drop. Finally, student should gently press out any bubbles and use a paper towel to dab any excess water off of the silde.)*
- Given the following items, set up an experiment to show the effects of osmosis: two cups, water, salt, 2 carrots, string, paper towels. Briefly describe your anticipated results. *(Student should pour water in each glass, putting salt in one of the glasses. Student should then tie a string around each carrot, and put one carrot in each glass. Student should describe results as follows: the carrot in the salt water will be rubbery and smaller, thus the string will be loose. The carrot in the fresh water will be rigid and bigger, thus a tighter string. This is due to osmosis—water moved out of the salt water into the carrot and out of the fresh water into the carrot, because water travels from areas of higher water concentration to lower water concentration.)*
- Given the genotypes of the two parents on the index cards (one with Bb and one with bb), tell the 4 possible genotypes and phenotypes of the children. Assume that B=brown eyes and b=blue eyes. *(Students should write four possible genotypes and phenotypes for the offspring as follows: Bb(Brown eyes) Bb(Brown eyes) bb(blue eyes) bb (blue eyes).)*

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

Active Transport – Movement of materials into or out of a cell that requires the use of energy

Alleles - Any of several forms of a gene, usually arising through mutation, that are responsible for hereditary variation.

Angiosperms – Plants with flowers

Animal - Organisms in the kingdom Animalia.

Annilida - Invertebrate worms that have segmented bodies, such as earthworms.

Aquatic - Living in the water

Arboreal - Living in trees

Asexual Reproduction – Reproduction requiring only one parent

ATP – Molecule used for energy in cells

Autotroph – organism that can create its own energy

Autotrophs – Organisms that get energy from photosynthesis

Bilateral Symmetry - Body plan in which the left and right side are mirror images.

Binary Fission – Asexual reproduction in which the parent organism splits into two identical offspring

Body cavity - A space inside an organism used for digestion or more.

Brackish - Slightly salty

Budding – Process of reproduction where a small appendage, or "bud" grows on the parent organism, eventually breaking off to form its own organism

Camouflage - blending in with non-living things around you

Carnivore - Meat-eater

Cartilage - The flexible material that makes up the human outer ear and nose, and the body of some fish

Cell – The smallest objects that can do all the things needed for life

Cell – the smallest part of an organism still considered to be alive

Cell – The smallest structure still considered to be living

Cell Division – Process in which one cell becomes two cells

Cell Membrane – Structure on the edge of a cell that determines what does or doesn't go into a cell

Cell Wall – Organelle found in plant cells that provides support and protection

Cell Wall – Structure on the outside of a cell that protects it from harmful substances trying to enter

Cellular Respiration – Process in which chemical energy stored in glucose is changed to chemical energy stored in ATP

Chloroplast – Organelle found in plant cells that allows sunlight to be used to make food

Chromosome – Area of the cell in which the genetic information is found

Class - Group of similar living things in the same phylum or sub-phylum

Classification – organizing things into groups

Classification – Putting things into groups

Classify - Group; as in grouping organisms into hierarchical categories.

Cnidaria - Invertebrates that have radial symmetry and include the jellyfish.

Codominance - Of or pertaining to two different alleles that are fully expressed in a heterozygous individual.

Commensalism – Symbiotic relationship in which one organism benefits while the other is unaffected

Complete digestive tract - A digestive tract that has two openings, the mouth and the anus.

Concentration – The amount of a substance in a certain area

Control Group – group that receives a no change in an experiment

Corolla – Collective term for all the petals of a flower

Cross-Pollination – Method of reproduction in angiosperms where the pollen from a plant goes into the stigma of a different plant

Cytoplasm – Material inside the cell membrane

Data – Information collected during an experiment

Daughter Cells – The cells at the end of cell division

Decomposers – Bacteria that get their energy by breaking down waste and dead organisms

DNA - An extremely long macromolecule that is the main component of chromosomes and is the material that transfers genetic characteristics in all life forms, constructed of two nucleotide strands. The genetic information of DNA is encoded in the sequence of the bases and is transcribed as the strands unwind and replicate.

DNA – Genetic material that has all the information about a cell

Dominant Trait - A trait that will appear in the offspring if one of the parents contributes it.

Dormant – State in which seeds do not sprout

Ecology – branch of life science that studies the interaction of living things with other living things and non-living things

Energy – The ability to cause a change

Environment - The external factors surrounding and affecting an organism at any given time.

Eukaryote – A cell with a nucleus

Eukaryotes – Cells that have a nucleus

Eukaryotic – Having cells with nuclei

Evidence – an observation of a thing, group of things, or a process that takes time

Experimental Group – group that receives a change that is being tested during an experiment

F1 generation - The offspring of the P generation.

F2 generation - The offspring of the F1 generation.

Family - Organisms descended from the same ancestors sharing relatively similar characteristics.

Flatworm - Worms lacking a body cavity found in the phylum platyhelminthes.

Food Web – model showing what living things eat what in a certain area

Frugivore - fruit-eater

Gastrovascular cavity - A large cavity having both digestive and circulatory functions.

Gene - The basic physical unit of heredity; a linear sequence of nucleotides along a segment of DNA that provides the coded instruction for synthesis of proteins.

Generalist - animal that will eat multiple types of food

Genetic disorders - Inherited genetic defects.

Genetics - The science of heredity, dealing with resemblances and differences of related organisms resulting from the interaction of their genes and the environment.

Genotype - The genetic makeup of an organism or a group of organisms with reference to a single trait, set of traits, or entire complex of traits.

Genus - Groups of species that are structurally similar or phylogenetically related.

Golgi Apparatus – Organelle that receives proteins and prepares them to be sent to other places in the cell or the body

Gregor Mendel - An Austrian monk and biologist. He developed the fundamental laws of genetics through his experiments with pea plants.

Gut - An area in an organism used for digestion.

Gymnosperms – Plants with seeds considered "naked," because they are not covered in fruit

Herbivore - Plant-eater

Heredity - The transmission of genetic characters from parents to offspring.

Heterotroph – organism that must eat other organisms to get its energy

Heterotrophic – Needing to eat in order get energy

Heterozygous - Having dissimilar pairs of genes for any hereditary characteristic.

Homeostasis – process of maintaining a stable internal environment in an organism

Homozygous - Having similar pairs of genes for any hereditary characteristic.

Hormones – Chemicals which cause changes in an organism based on things going on in the outside environment.

Host – Living organism from which another organism, such as a fungus, takes nutrients

Human Genome Project - A global effort, completed in 2003, to sequence and map all human genetic information.

Hypothesis – a possible answer to a scientific question

Incomplete digestive system - A digestive tract that has only one opening.

Innate Behavior - animal behavior that does not need to be learned

Insectivore - Insect-eater

Invertebrate - Animals without a backbone.

Kingdom - Large group of living things with common characteristics; the domain in which living organisms are classified.

Laws of heredity - The laws of the inheritance of genetic information.

Life Science – the study of living things and how they interact with their environment

Medusa - Cnidarian with a bell-shaped body directed downward.

Mendel's Law of segregation - Mendel's law postulates that each organism receives two copies of its genes (what he called "inheritance factors." Furthermore, when reproducing (sexually) they can only give one copy, such that each offspring receives one paternal and one maternal copy of the gene.

Migration - Movement from one place to another

Mitochondrion – Organelle that makes energy available for the cell

Model – a representation of something else

Multi-cellular – Being made of more than one cell

Mutualism – Symbiotic relationship in which both organisms benefit

Nematoda - Invertebrate worms that include the roundworms.

Nonvascular Plants – Plants without vascular tissue

Nuclear Membrane – Structure that surrounds and protects the nucleus

Nucleus – Organelle that determines which proteins will be made

Nucleus – Part of the cell that controls the cell's functions

Nutrient – Substances that are helpful to living things

Observation – anything noticed using the five senses

Omnivore - Eating meat and plants

Organ – A group of tissues working to do the same job

Organism – a living thing

Organism – Living thing

Osmosis – Movement of water through passive transport

P generation - The parent generation.

Parasitism – Symbiotic relationship in which one organism benefits while the other is harmed

Parent Cell – The cell at the start of cell division

Passive Transport – Movement of materials into or out of a cell without the use of energy

Pedigree analysis - A graphic showing the inheritance of a trait or traits throughout a lineage.

Phenotype - The appearance of an organism resulting from the interaction of the genotype and the environment.

Phloem – Vascular tissue that carries sugars

Photosynthesis – Process in which light from the sun is changed into chemical energy

Photosynthesis – Process in which plants convert sunlight into the energy they need to survive

Phylum - Group of living things in the same kingdom with common characteristics; a principal taxonomic category that ranks above class and below kingdom.

Placebo – inactive substance looking similar to the medication being tested

Placental - group of mammals in which fetuses are nourished by a placenta

Platyhelminthes - Invertebrate worms that include the flatworms and tapeworms.

Pollen – The male gametophyte in angiosperms

Polygenic traits - Traits controlled by two or more genes.

Polyp - Cnidarian with a cup-shaped body directed upward.

Prokaryote – A cell without a nucleus

Prokaryote – Cell without a nucleus

Protozoa – Animal-like protists

Punnett Squares - Tables used to determine the probability of offspring inheriting traits from their parent(s).

Radial symmetry - A body plan in which any cut through the center results in two identical halves.

Recessive Trait - A trait that must be contributed by both parents inorder to appear in the offspring.

Recombinant DNA - DNA combined from two or more sources.

Reproduction – process of creating new organisms

Restriction enzymes - Enzymes used to cut DNA at specific points.

Roundworm - A nematode worm (class Phasmida), esp. a parasitic one found in the intestines of mammals.

Scientific method –a series of steps that can be used to answer questions and solve problems

Segmentation - A body plan that has repeated units or segments.

Segmented worm - A worm composed of repeating units (segments).

Self-Pollination – Method of reproduction in angiosperms where the pollen from a plant goes into the stigma of the same plant

Sepals – Outside layer of a flower that covers it before it opens

Sex-linked inheritance - Inheritance linked to the sex chromosomes (the X or Y chromosomes).

Sexual Dimorphism - having males and females that look very different

Sexual Reproduction – Reproduction requiring two parents

Species - Organisms capable of mating with one another.

Spirilli – Bacteria shaped like spirals

Stigma – Female part of a flower

Symbiotic – Long-term relationship between two organisms

Tapeworms - Intestinal parasites in the phylum Platyhelminthes.

Terrestrial - Living on land

Theory – A group of ideas that explains why or how something happens

Traits - A genetically determined characteristic.

Unicellular – Being made of only one cell

Vascular Seedless Plants – Plants containing vascular tissue, but no seeds

Vertebrate - Animal with several distinguishing characteristics, including the presence of a spinal column or backbone of bone or cartilage.

Wingless insects - Insects without wings.

Xylem – Vascular tissue that carries water and minerals