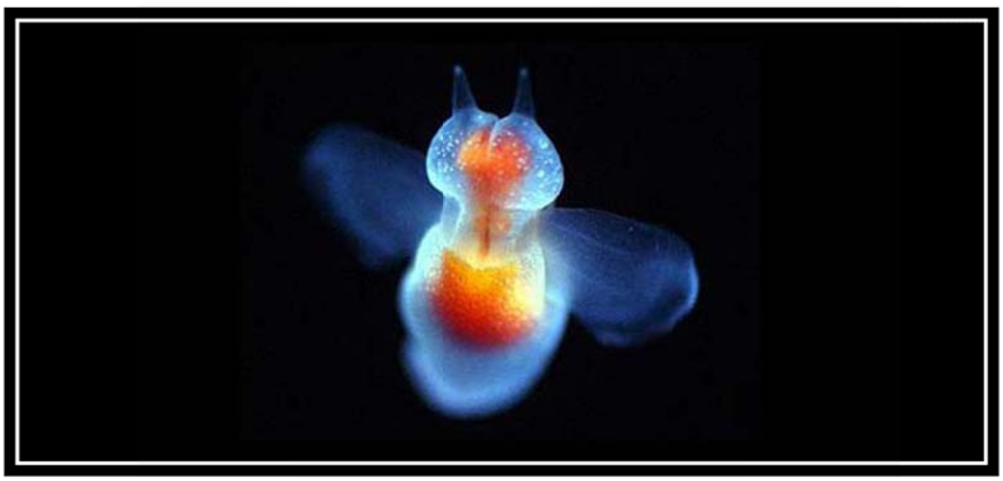
LIFE SCIENCE 1

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.



Created by Aurora Lipper, Supercharged Science

www.SuperchargedScience.com

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

Table of Contents

Introduction

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

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

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

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

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

Good luck with this Life Science unit!

For the Parent/Teacher:
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 doing 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 (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.
- 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.

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

Lab Safety

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

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

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

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

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

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

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

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

Lesson #1: How to Use a Microscope

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

Experiment

1. 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.
2. Now look at the objective lenses. They're on the nose of the microscope, and there are 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?
3. 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

4. Carefully cut a single letter (like an "a" or "e") from your lab sheet here → a e

5. 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.
6. Lower the stage to the lowest setting using the coarse adjustment knob (look at the *stage* when you do this, not through the eyepiece).
7. Place your slide in the stage clips.
8. Turn the diaphragm to the largest hole setting (open the iris all the way).
9. Move the nose so that the lowest power objective lens is the one you're using.
10. Bring the stage up halfway and peek through the eyepiece.
11. 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.
12. 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!)
13. Use the fine adjust to bring it into sharp focus.
14. 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'.
15. Give the slide a half turn and draw another picture in a new circle. Label this one 'upside-down'.
16. 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.
17. 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?
    What effect do the two lenses have on the letter image as you move it around?
19. 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.

20. 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.
21. Lower the stage to the lowest setting and rotate the nose piece to the lowest magnification power.
22. Place the slide on the stage in your clips.
23. 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.
24. Sketch what you see (don't forget the title and mag power!) in the third circle in *Microscope Lab Data* below.
25. 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.
26. 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

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.

Exercises

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

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 need 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)

Experiment

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

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.

Exercises

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

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

Experiment

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 it 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!

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.

Exercises

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

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

Experiment

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?

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. 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).

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.

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 think 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.

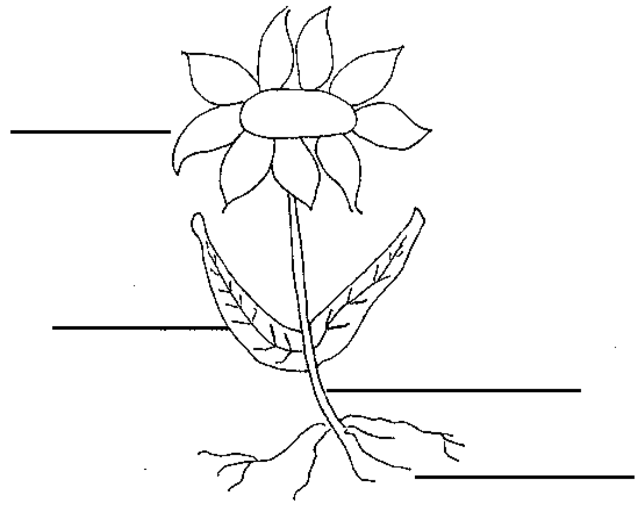
Many people have admired the beautiful colors and smells of flowers, and this is no accident. The whole point of many flowers is to be attractive to animals, generally insects, to help in reproduction.

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.

Exercises

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

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)

Experiment

1. First, find four celery stalks about the same size with leaves still attached.
2. Mix up a four-cup batch of colored water using food dye and cold 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

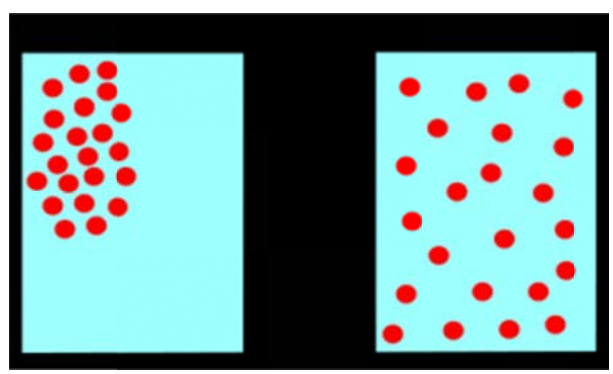
Time Celery Was in Water	Distance Water Traveled up Celery

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.

Exercises

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

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'll see that the potato slice in the fresh water became a little stiffer, while the potato in salt water became rather flimsy. The question is…why?

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

Experiment

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, overnight is better.
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

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.

Exercises

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

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 the side with 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

Experiment

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)*

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.

Exercises

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

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

Experiment

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

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.

Exercises

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

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.)

Experiment

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

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.

Building Tips:

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?

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!

Experiment

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.
3. 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.

What to Learn Hygrometers 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.

Materials

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

Experiment

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

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.

Exercises

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!

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

Experiment

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?	

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.

Exercises

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

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? 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.

What to Learn 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

Experiment

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

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.

You will get to 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. You can also identify the role of different plants and animals in their eco column: producers, consumers, and decomposers. Specifically, look for how animals eat plants or other animals for food, if they use plants or even other animals for shelter and nesting; producers and consumers (herbivores, carnivores, omnivores, and decomposers) and how they are related in food chains and food webs. Also see if you can determine how they compete with each other for resources in an ecosystem, and how matter is transferred from one organism to others in the food web over time. You'll want to get a feel for the relationships between the organisms and the physical environment in the big picture.

Exercises

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

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

Experiment

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.

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.

Carnivorous Greenhouse Data Table

Date	Plant Type	Growth	Eating Habits

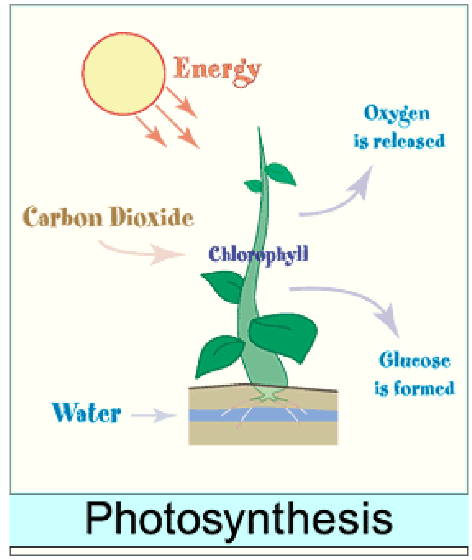
Reading

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.

Exercises

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



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

Experiment

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

Reading

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. 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.

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.

Exercises

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

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

Experiment

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

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.

Exercises

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

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 the process of cell division for eukaryotes, or cells with nuclei. It is more complex than cell division for cells without nuclei (prokaryotes). Cells divide to increase their numbers through a process of mitosis, which results in two daughter cells with identical sets of chromosomes. You'll learn how to define the four stages of mitosis while identifying the four stages of mitosis in onion cells using a microscope.

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

Experiment

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:

Mitosis Microscope Data

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.

Exercises

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

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.

What to Learn 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? 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.

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

Experiment

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	

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 2nd and the other half on the 4th 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).

Exercises

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?

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 fruit 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

Experiment

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:

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.

Exercises

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

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!

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

Experiment

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.
3. 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!).

Reading

Can you think of a machine that sucks things up? If you're thinking "a vacuum", you're right! The question is, what type of vacuum do we need? A big industrial one, or a little handheld model? The answer is: it depends on what you plan to use it for. It would take a long time to vacuum your entire house with a car vacuum, and it wouldn't be nearly as powerful as it needed to be.

For collecting bugs, if we use too powerful of a vacuum to extract them from their environment, they're going to be crushed so we can't observe their natural behavior (it's like trying to observe bugs that are already squashed on a windshield). Our 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). And *you* get to provide the suction power.

Exercises

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

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 Certain bugs are attracted to heat, but then they move around so we can't observe them easily, especially if they are in the dirt itself. You're going to learn how to build a light trap to pull the light-loving bugs up out of the dirt so you can observe them like a real scientist.

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.

Experiment

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:

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.

Exercises

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!*

Experiment

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.
3. 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 Using thesimple optics of a waterscope (also called an aquascope), you'll be able to observe organisms in water.

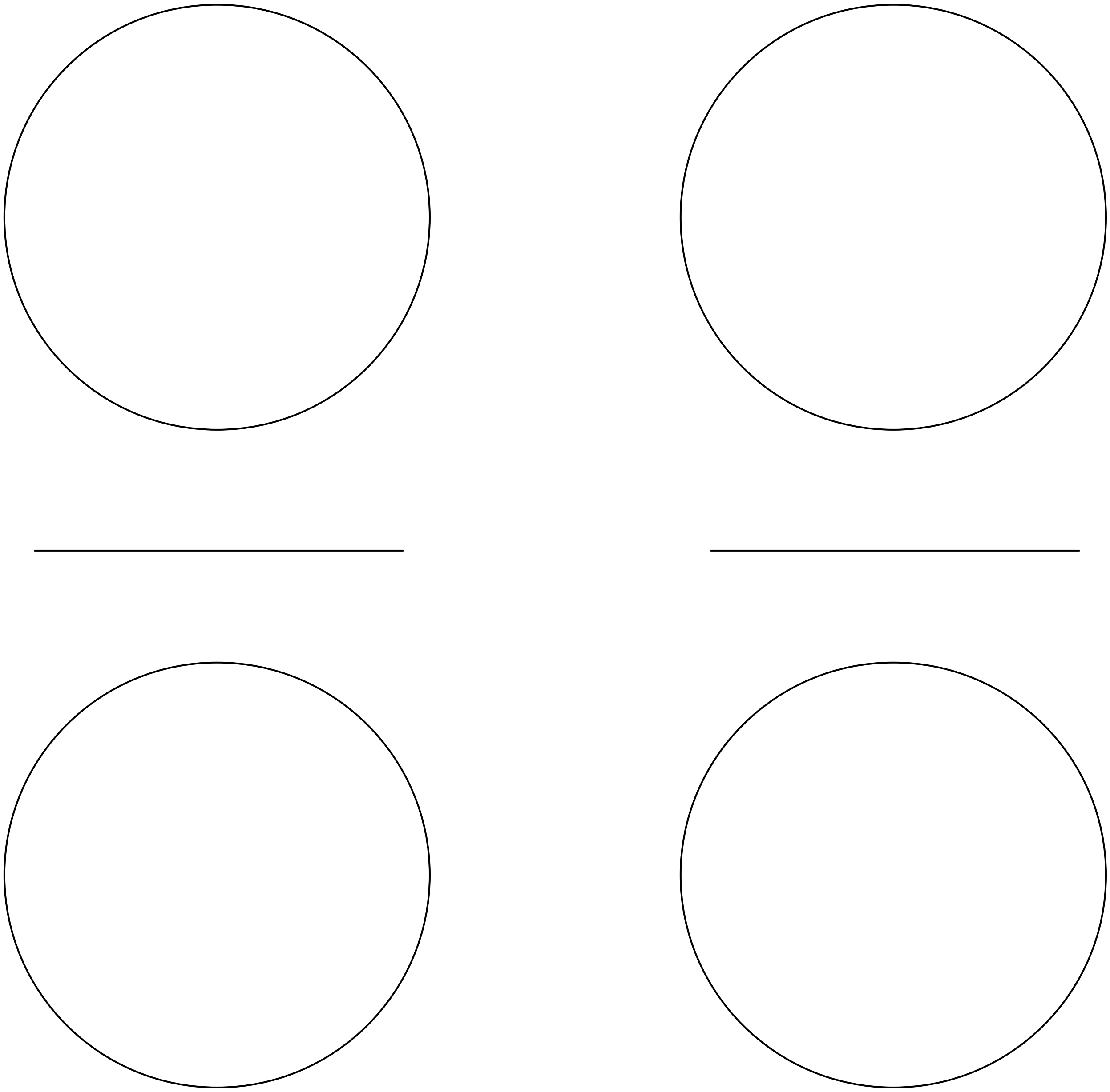
Materials

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

Experiment

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:

Waterscope Diagrams



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.

Exercises

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

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

Experiment

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.

Protozoa Microscope Diagrams

Reading

Every living thing, from tiny bacteria to giant oak trees, began life as a single 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.

Protozoa have different shapes, so you will examine samples of your protist farm every few days, to see what different shapes occur.

Exercises

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

1. 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.
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

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.

Experiment

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.
3. 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 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.

What to Learn We're going to learn how to extract DNA from any fruit or vegetable you have lying around the fridge. 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

- 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

Experiment

1. 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!
2. 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.
3. 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.
4. 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

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.

Exercises

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.

Experiment

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.
3. 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! Genetics asks which features are passed on from generation to generation in living things. It also explains 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.

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

Materials

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

Experiment

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?

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?

18. Draw the family:

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.

Exercises

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

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

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

Student Worksheet

This is your chance to show how much you have picked up on important key concepts, and if there are any holes. You also will be working on a homework assignment as you do this test individually with a teacher.

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:

- Demonstrate the proper way to mount a copper penny.
- Demonstrate the proper way to mount pond water.
- 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.
- 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.

Answers to Exercises and Quizzes

Lesson #1: How to Use a Microscope

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.)

Lesson # 2: Wet Mount and Staining

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)

Lesson #3: Heat Fixes

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.)

Lesson #4: Plant Press

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.)

Lesson #5: Celery Stalk Water Race

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.)

Lesson #6: Osmosis in Potatoes and Beans

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.)

Lesson #7: Cool Carrot Osmosis

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.)

Lesson #8: Membranes
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)

Lesson #9: Water Cycle Column
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 – the salt says in the soil, because only water evaporates.)
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 by simulating the CO, CO_2, and NO_x gases.)

Lesson #10: Homemade Hydrometer
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.)

Lesson #11: Worms!
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.)

Lesson #12: Eco Column
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).

Lesson #13: Carnivorous Greenhouse
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)

Lesson #14: Carbon Dioxide and Photosynthesis
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)

Lesson #15: Einstein's Garden
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)

Lesson #16: Onion Mitosis
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.)

Lesson #17: Terraqua Column
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.*)

Lesson #18: Who Eats Whom?
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))

Lesson #19: Insect Aspirator
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).

Lesson #20: Berlese Funnel
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)

Lesson #21: Waterscope
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.)

Lesson #22: Protozoa in the Grass

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.)

Lesson #23: Extracting DNA in Your Kitchen

1. What are fruits and veggies made of? (water, cellulose, sugars, proteins, salts, and DNA.)
2. What does DNA stand for? (deoxyribonucleic acid)
3. 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.)
4. What is a gene? (Genes are individual codes for making proteins that are passed on from generation to generation.)
5. 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.)

Lesson #24: Tracking Traits

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.)

Life Science 1 Quiz

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

   1. cheek cells ____*heat fix*________
   2. a strand of hair ________*dry mount*_____
   3. 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. ($6CO_2 + 6H_2O$ *+ Light Energy –>* $C_6H_{12}O_6 + 6O_2$ *)*

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)*

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