7^{th} Grade

Fall 2019 Lesson Plans

Vanderbilt Student Volunteers for Science

http://studentorg.vanderbilt.edu/vsvs/

VOLUNTEER INFORMATION

Team Member Contact Information

Name:____ Phone Number:______________________

Name:____ Phone Number:______________________

Name:____ Phone Number:______________________

Name:____ Phone Number:______________________

Name:____ Phone Number:______________________

Teacher/School Contact Information

School Name: ___________________________________ Time in Classroom: ____________________

Teacher's Name: __________________________________ Phone Number: ______________________

VSVS INFORMATION

VSVS Educational Coordinator:

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Vanderbilt Protection of Minors Policy: As required by the Protection of Minors Policy, VSVS will keep track of the attendance – who goes out when and where.

https://www4.vanderbilt.edu/riskmanagement/Policy_FINAL%20-%20risk%20management%20v2.pdf

Before You Go:

- The lessons are online at: http://studentorg.vanderbilt.edu/vsvs/
- Email the teacher prior to the first lesson.
- Set a deadline time for your team. This means if a team member doesn't show up by this time, you will have to leave them behind to get to the school on time.
- Don't drop out from your group. If you have problems, email Paige or one of the co-presidents, and we will work to help you. Don't let down the kids or the group!
- If your group has any problems, let us know ASAP.

Picking up the Kit:

- Kits are picked up and dropped off in the VSVS Lab, Stevenson Center 5234.
- The VSVS Lab is open 8:30am – 4:00pm (earlier if you need dry ice or liquid N_2).
- Assign at least one member of your team to pick up the kit each week.
- Kits should be picked up at least 30 minutes before your classroom time.
- If you are scheduled to teach at 8am, pick up the kit the day before.
- There are two 20 minute parking spots in the loading dock behind Stevenson Center. Please do not use the handicap spaces – you will get a ticket.

While you're there – Just relax and have fun!

September						
SUN	MON	TUES	WED	THU	FRI	SAT
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25 Team Leader Training 6-8 pm	26	27 VSVS Day of Service 3-5pm	28
29 Team Leader Training 6-8pm	30 Team Training 5^{th} &7^{th} Grade (come during your normal lesson time)					

October

SUN	MON	TUES	WED	THU	FRI	SAT
		1 Team Training 5th &7th Grade (come during your normal lesson time)	2 Team Training 5th &7th Grade (come during your normal lesson time)	3 Team Training 5th & 7th Grade (come during your normal lesson time)	4 Team Training 5th &7th Grade (come during your normal lesson time)	5
6	7 Team Training 6th & 8th Grade (come during your normal lesson time)	8 Team Training 6th & 8th Grade (come during your normal lesson time)	9 Team Training 6th & 8th Grade (come during your normal lesson time)	10 Team Training 6th & 8th Grade (come during your normal lesson time)	11 Team Training 6th & 8th Grade (come during your normal lesson time)	12
13	14 Lessons, Week 1	15 Lessons, Week 1	16 Lessons, Week 1	17 Lessons, Week 1	18	19 Mega Microbe 9am-2pm
20	21 Lessons, Week 2	22 Lessons, Week 2	23 Lessons, Week 2	24 Fall Break (lessons scheduled 10/24 will be moved to the week of 11/14)	25 Fall Break	26
27	28 Lessons, Week 3	29 Lessons, Week 3	30 Lessons, Week 3	31 Lessons, Week 3		

November

SUN	MON	TUES	WED	THU	FRI	SAT
					1	2
3	4 Lessons, Week 4	5 Lessons, Week 4	6 Lessons, Week 4	7 Lessons, Week 4	8	9
10	11 Veterans Day, Metro Schools Closed	12 Make ups, Week 1	13 Make ups, Week 1	14 Make ups, Week 1	15	16
17	18 Make ups, Week 2	19 Make ups, Week 2	20 Make ups, Week 2	21 Make ups, Week 2	22	23
24	25	26	27	28	29	30

CLASSROOM ETIQUETTE

Follow Metro Schools' Dress Code!

- No miniskirts, shorts, or tank tops.
- Tuck in shirts if you can.
- Please dress appropriately.

Metro student standard attire guideline:
http://jtmoorems.mnps.org/pages/JohnTrotwoodMooreMiddle/About_Our_School/8998762518461552450/Dress_Code

COLLEGE Q&A SESSION

VSVS members should be candid about their experiences and emphasize the role of hard work and a solid body of coursework in high school as a means to get to college.

- Email the teacher prior to the first lesson.
  - They may want to have the students write down questions prior to your lesson.
  - They may also want to have a role in facilitating the discussion.
- Finish the experiment of the day and open up the floor to the students.
- Remind them of your years and majors and ask if they have specific questions about college life.
- If they are shy, start by explaining things that are different in college.
  - Choosing your own schedule, dorm life, extracurricular activities, etc.
  - Emphasize the hardworking attitude.

The following are some sample questions (posed by students):

- When is bedtime in college? Does your mom still have to wake you up in college?
- How much does college cost?
- What do you eat in college and can you eat in class in college?
- How much homework do you have in college?

DIRECTIONS TO SCHOOLS

H.G. HILL MIDDLE SCHOOL: 150 DAVIDSON RD **615-353-2020**

HG Hill School will be on the right across the railroad lines.

HEAD MAGNET SCHOOL: 1830 JO JOHNSON AVE **615-329-8160**

The parking lot on the left to the Johnston Ave.

J.T. MOORE MIDDLE SCHOOL: 4425 GRANNY WHITE PIKE **615-298-8095**

From Lone Oak, the parking lot is on the right, and the entrance into the school faces Lone Oak, but is closer to Granny White.

MEIGS MIDDLE SCHOOL: 713 RAMSEY STREET **615-271-3222**

Going down Ramsey Street, Meigs is on the left.

ROSE PARK MAGNET SCHOOL: 1025 9th AVE SOUTH **615-291-6405**

The school is located on the left and the parking is opposite the school, or behind it (preferred).

WEST END MIDDLE SCHOOL: 3529 WEST END AVE **615-298-8425**

Parking is beside the soccer field, or anywhere you can find a place. Enter through the side door.

<u>EAST NASHVILLE MAGNET MIDDLE SCHOOL: 2000 GREENWOOD AVE</u> **615-262-6670**

<u>MARGARET ALLEN MIDDLE SCHOOL: 500 SPENCE LN</u> **615- 291- 6385**

From West End down Broadway, take 1-40E to exit 212 Rundle Ave. Left on Elm Hill to Spence Lane.

VANDERBILT STUDENT VOLUNTEERS FOR SCIENCE

http://studentorg.vanderbilt.edu/vsvs

SURVIVOR

Goal: To explain how the environment helps determine what traits certain species possess.

TN State Standards: 8.LS.4.3, 8.LS.4.4

VSVSer Lesson Outline

______ **I. Introduction**

a. What is a trait?

b. What is natural selection?

______ **II Activity**

Students will make their creature and will identify its traits.

______ **III. Activity**

Students will play the game SURVIVOR (15-20 minutes)

______ **IV What Creatures Survived?**

Students will look at score sheet and describe what happened to their creature (5 minutes).

What traits were most advantageous to survival? (3-5 minutes)

Instructor will define and explain natural selection (3-5 minutes)

Instructor will give an example of natural selection (3-5 minutes)

________ **V. Review**

LOOK AT THE VIDEO BEFORE YOU GO OUT TO YOUR CLASSROOM

https://studentorg.vanderbilt.edu/vsvs/lessons/

USE THE PPT AND VIDEO TO VISUALIZE THE MATERIALS USED IN EACH SECTION.

1. Before the lesson:

In the car ride, read through this quiz together as a team. Make sure each team member has read the lesson and has a fundamental understanding of the material.

Survivor Lesson Quiz

1. What is a trait?
2. What is natural selection?
3. What is an adaptation?
4. Give an analogy that explains traits, natural selection, and adaptation.
5. How do students determine if their creature went extinct at the end of the survivor game?
6. How will students determine whether individual traits were beneficial or not?

Unpacking the kit;

Divide class into 10 groups.

Part II: Activity – students make their creatures.

Give each group a plastic bag containing creature parts

Give each pair a handout of light and dark-colored peppered moths and the Traits handout.

Give each student an observation sheet

Part III. Activity – Survivor Game

VSVSers will need the scenario list and red and green poker chips.

I. INTRODUCTION

Learning Goals: Students understand basic genetics terms and concepts. Also, they are able to understand how this plays into natural selection, what natural selection is, and some examples of natural selection.

Why is the science in this lesson important?

As its name implies, natural selection happens in nature without human interference, but a similar process called artificial selection still relies on the same principles. A rancher in Arizona is breeding his cattle to consume less grass yet still produce more beef. Plants have been bred to create bigger and sweeter fruits. Humans are able to control the prevalence of traits by increasing the fitness of desired traits with selective breeding.

Ask students what they know about Charles Darwin.

- English naturalist born in the 1800's
- Studied different forms of life around the world.
- Darwin proposed his theory of **natural selection**
- Concluded that organisms changed over time to better survive in their specific environments.
- "I have called this principle, by which each slight variation, if useful, is preserved, by the term Natural Selection." - Charles Darwin, *On the Origin of Species*

a. What is a Trait?

Ask the class the following:

1. Why do people look different from each other? *Answer: Because of differences in traits.*
2. Ask students to define the word **"trait".**

   Answers should include: Traits are mostly physical characteristics or features that organisms have, e.g., hair color.

   A trait can be passed on to the offspring.

Examples of Traits:

Hair color, Eye color, Skin color, Height, Weight,, Hitchhiker's thumb, Left/right handed, Ability to curl the tongue, Morton's toe, Attached/unattached earlobes, Nose shape, Hair texture

3. Ask students, "Why are there variations in a physical characteristic?"

   For example, there are many differences in hair colors (brown, red, blonde, etc.).

   Traits are influenced by genes. Genes carry information about traits which our parents have and pass down to us.

   Different combinations of genes influence an individual's features. These variations help make a person unique.

   For example, there are different versions of a gene which influence hair color. Parents will pass down different variations of a gene to their children, causing each of them to possibly have a different hair color.

- Traits, however, aren't *only* influenced by genes. How we live in the environment also determines our traits. For example, height and weight are influenced both by the genes we have from our parents and by what we eat.

b. What is Natural Selection?

Ask students what they know about Natural Selection. Answers should include:

- It is the process by which an organism's traits are passed on or selected based on their environment.
- Some organisms have traits that allow them to better survive in their environment. For example, an arctic fox is white, which allows it to blend into its surroundings (snowy tundra). This "camouflage" makes it easier for the fox to hunt its prey, thus improving his chances of survival.
- The organisms that manage to survive then reproduce, passing on the genes for their advantageous traits to their offspring.
- If a gene leads to a trait that gives a significant enough advantage to the organism, then the organisms with that gene will eventually out-populate those without the gene
- This is why people describe the theory of natural selection as "the survival of the fittest".

Examples of Natural selection:

Tell the students that you are going to show them a real-world example of natural selection.

- Tell students to look at the handout of pictures of the peppered moths
- Prior to the 1800's, the peppered moth, found in England, was mostly light-colored. Dark colored moths were rare.
- The peppered moth liked to hang out on tree trunks. Industrial waste created during the Industrial Revolution darkened tree trunks where these peppered moths lived.
- Light-colored moths were spotted easily by predatory birds on the dark tree trunks and were eaten before they could reproduce.
- In contrast, the dark-colored moths blended in better with the dark tree trunks, making it more difficult for the birds to spot them. Thus, the dark-colored moths survived and reproduced.

Other Natural selection examples:

- Some insects have become immune to pesticides e.g. DDT is no longer effective in preventing malaria in some places
- Rat snakes come in a huge variety of colors depending on their environment.
- The most colorful peacock tails are the most effective at attracting a mate, so the tails got larger and more colorful and became what we are familiar with today.
- Deer mice started out dark brown to blend in with the forest, but those mice that moved to sandy desert in Nebraska adapted to become a light brown in order to blend in. The darker mice were killed by predators.
- When nylon was invented in the 1940's, bacteria evolved that were able to eat the nylon.
- All humans used to become lactose intolerant as they became adults. However, when cows were domesticated, most humans acquired the ability to consume lactose in adulthood.

c. Traits that help organisms to survive in a specific environment are called adaptations.

An adaptation is an inherited trait that helps an organism survive.

Examples of adaptations:

- Lizards with tails that fall off to escape predators
- Bats use sonar to hunt at night
- Milkweed produces a toxic substance to deter predators
- Spiders spin webs to catch prey
- Opossums play dead to avoid predators
- Rosebushes have thorns

II. ACTIVITY – STUDENTS MAKE THEIR CREATURES.

Learning Goals: Students make creatures with specific genetic variation and see how simple variation can lead to drastically different levels of survival.

Divide class into 10 groups.

Have class look at the list of Traits and variations. As a class, discuss the benefits and detriments for the first trait – Leg Length. Some examples are given.

Trait	Variation	Beneficial for:	Detrimental for:
Leg Length	*Long*	Can run fast	Cannot hide in grassland
	Short	Can hide in grassland	Cannot run very fast
Wings	*Wings*	Can fly away	Are easily damaged
	No Wings	Not in the way when walking through bushes	Cannot fly away
Foot Shape	*Talon*	Can climb structures	Cannot swim in water
	Webbed	Can swim in water	Cannot climb structures
Tail Length	*Short*	Allows you to be nimble	Cannot swat flies
	Long	Can be used to fight the enemy	Makes a lot of noise when sneaking up on prey
Arm Length	*Short*	Short arms are stronger	Cannot reach food high off the ground
	Long	Arms slow you down running thru bush	Can reach food high off the ground
"Hand" Shape	*Claw*	Can pick up nuts	
	Paw	Can dig holes to lie in to keep cool	Cannot pick up nuts
Antenna Shape	*Star*		
	Knob		
Antenna Length	*Short*	Safe from lightning strikes	Cannot pick up cell phone signals
	Long	Can detect enemy	Can be struck by lightning
Beak Shape	*Crusher*	Can crush hard nuts	Cannot suck up nectar
	Trumpet	Can suck up worms	Cannot crush hard nuts
Ear Shape	*Mouse*	Easy to keep clean	Has lousy hearing
	Elephant	Has very good hearing	Ears stick out and can be seen by predators
Skin Color	*Red*	Can hide in a field of red flowers	Scares off fish
	Blue	Blends with water so difficult for seagulls to find you for supper	
	Purple		Scares off fish
Eye Color	*Red*		
	Green		
	Red and Green		

Tell the students that they are going to build a creature that they believe can withstand a variety of environmental changes.
Have each group decide which Trait variation they want for their creature. Circle that variation and give the reason (benefit) for choosing it.

Note: Some possible benefits/detrimental factors are listed on the next page, (if groups need help deciding which variation to choose)
Tell the group to build their creature, using the Trait variations that they have listed

1. There are a few rules:
    a. Creatures can have only ONE variation of a Trait. For example, you cannot have one web foot and one talon foot. Arm lengths, hand shapes, ear shapes etc have to be the same.

b. You cannot change your creature after the game begins

After the creatures have been built, pass out the SURVIVOR Student Handout observation sheet..

III. Activity

Learning Goals: Students make creatures with specific genetic variation and see how simple variation can lead to drastically different levels of survival.

- Students will now play the game of SURVIVOR.
- Explain that this game simulates how different creatures will "survive" in different environments.
- There are eleven scenarios that depict an environmental situation.
- In each situation, one variation of a trait will help some creatures survive and the other variation(s) of the trait will not help the others.

The Rules:

- All teams start with zero chips.
- A scenario is read by a VSVS member. Each creature possesses a trait that is either an advantage or disadvantage under the change in the environment.
  - o Creatures that possess the advantageous variation will reproduce, represented by a green chip.
  - o Creatures that possess the disadvantageous variation will get a red chip.
  - o After each scenario, pass out a red or green chip to the groups.
- At the end of the game, students with more green chips than red chips have survived, but those with more red chips than green chips have gone extinct.
- The students will also keep track of the scores of each individual trait on the tally sheet.
- Note – there may be some scenarios where students could argue that while one particular trait their creature possesses might be a disadvantage in that situation another one might be advantageous. For example, in scenario #8, having short arms means that you can't reach the leaves on the trees but if the short-armed creatures also had talon feet they would be able to climb the trees to get leaves. If these arguments come up, use your judgement to allot poker chips! Explain that natural selection is complicated and many factors influence it. This is just a **MODEL**, and all models have imperfections.

Scenario #1

A severe drought occurs during the wet season in your environment. Most of your main foods sources have died during the drought, leaving you with tough seeds to eat.

Ask students "what trait is advantageous for survival, what trait is disadvantageous"?

If you have a trumpet beak, you are unable to break open these seeds. If you have a crusher beak, you are able to break open these seeds, so you can better survive and reproduce.

Score: Crusher beaks +1, Trumpet beaks -1

Give students the appropriate chips

Scenario #2

The lack of food during the drought has caused many of the creatures to find nourishment by feeding on hard shelled marine animals in the nearby ocean.

Ask students "what trait is advantageous for survival, what trait is disadvantageous"?

If you have paw hands, you have a difficult time cracking open shellfish to eat. If you have claws, you are able to easily open shellfish to eat, so your creature is more fit and able to reproduce.

Score: Claw hands +1, Paw hands -1

Give students the appropriate chips

Scenario #3

Tall trees in your environment have survived the drought. To eat berries nuts or leaves, you must climb high up into the trees.

Ask students "what trait is advantageous for survival and reproduction, what trait is disadvantageous"?

If you have webbed feet, you are unable to climb the tree. If you have talon feet, you are able to climb up the tree.

Score: Talon feet +1(get green chip), Webbed feet -1(get red chip)

Give students the appropriate chips

Scenario #4

The next wet season has finally came and brought with it plentiful rain. The rain nourishes a field of purple wildflowers.

Ask students "what trait is advantageous for survival, what trait is disadvantageous"?

If you have purple skin, you are able to hide in the field of wildflowers from predators. If you have red or blue skin, you are easily spotted and eaten by predators while in the field of wildflowers. The surviving creatures are more able to reproduce than those that do not survive.

Score: Purple skin +1(get green chip), Red or Blue skin, -1(get red chip) **Give students the appropriate chips**

Scenario #5

Various insects are attracted to star antennae because they mistake them for flowers to feed off of.

Ask students "what trait is advantageous for survival, what trait is disadvantageous"?

If you have star antennae, you are able to capture and eat bugs easily. If you have knob antennae, insects are not attracted to you and you are unable to catch the insects to eat them. The creatures that eat the bugs are more fit and able to reproduce.

Score: Star antennae +1(get green chip), Knob antennae -1(get red chip) **Give students the appropriate chips**

Scenario #6

Global warming has caused the sea level to rise. The high water levels have flooded your environment.

Ask students "what trait is advantageous for survival, what trait is disadvantageous"?

If you have web feet, you are able easily swim to higher ground to dry land. If you have talon feet, you are not able to get to dry land. Those creatures get to higher ground have safer places to reproduce and care for their young.

Web feet +1(get green chip), Talon feet -1(get red chip) **Give students the appropriate chips**

Scenario #7

A new factory is being built in your habitat, destroying much of your resources such as shelter and food.

Ask students "what trait is advantageous for survival, what trait is disadvantageous"?

If you have wings, you are able to fly to a new habitat to find resources, providing more food for you and your offspring. If you do not have wings, you must walk a long distance to find resources.

Score: Wings +1(get green chip), No wings -1(get red chip) **Give students the appropriate chips**

Scenario #8

You have found a new habitat. While searching for food one day, you need to reach high for leaves in the trees. *Ask students "what trait is advantageous for survival, what trait is disadvantageous"?*

If you have long arms, you are able to reach the leaves, and stay fit so that you can reproduce. If you have short arms, you cannot get close enough to the tree leaves.

Score: Longs arms +1(get green chip), Short arms -1(get red chip) **Give students the appropriate chips**

Scenario #9

A large forest fire is engulfing your environment. A member of your clan transmits a high frequency sound to warn you about the danger.

Ask students "what trait is advantageous for survival, what trait is disadvantageous"?

If you have elephant ears, you are able to clearly hear the warning, and survive on to reproduce. If you have mouse ears, you are not able to hear the warning.

Score: Elephant ears +1(get green chip), Mouse ears -1(get red chip) **Give students the appropriate chips**

Scenario #10

The forest fire is quickly consuming your habitat and you must escape.

Ask students "what trait is advantageous for survival, what trait is disadvantageous"?

If you have wings, you are able to quickly escape the fire and survive on to reproduce. If you do not have wings, you are not able to escape the fire.

Score: Wings +1(get green chip), No wings -1(get red chip) **Give students the appropriate chips**

Scenario #11

An abundance of acorns has fallen to the ground.

Ask students "what trait is advantageous for survival, what trait is disadvantageous"?

If you have a crusher beak, you can join in the feast, and you have plenty of energy to reproduce.

Score: Crusher Beak +1(get green chip), Trumpet Beak -1 (get red chip) **Give students the appropriate chips**

IV. WHAT CREATURES SURVIVED?

- Tell students to pair up a red chip with a green chip – they are effectively cancelling 1 advantageous trait with 1 disadvantageous trait.
- Set aside the paired chips. The remaining chips (all 1 color now) give you your final "score".
- Report these totals to a VSVS member who will write them on the board.

Final # and color of chips (green or red)

Creature 1	
Creature 2	
Creature 3	
Creature 4	
Creature 5	
Creature 6	
Creature 7	
Creature 8	
Creature 9	
Creature 10	

- Tell students that if a creature is holding only red chips, (and therefore had a negative final score), it has gone extinct. One group member should stand holding its extinct creatures for the class to see.
- If the creature is holding only green chips (and therefore had a positive score), that creature survived and reproduced. One group member should stand holding its survivor creature for the class to see.

Discovering which Variations Were the Most Advantageous

a. See if students can determine why some traits were more helpful than others. Students should reach the conclusion that "creatures" went extinct if their traits were not advantageous in the environment. On the other hand, traits which were advantageous helped the "creature" survive.

b. Have students holding creatures with green chips come to the front of the class and hold the creatures so that the class can see. Have the students determine if there are 2-3 traits common to the surviving creatures.
c. Have students with creatures that have gone extinct come to the front of the class. The class should determine if there are 2-3 traits common to the extinct creatures.

For example:

When food was scarce, it was helpful to have a crusher beak that allows a creature to eat 'hardy' foods such as seeds and nets.

Having Talon feet allowed a creature to scale certain objects.

Those with wings have greater mobility, allowing them to explore new habitats or escape from predators.

Explain that the students simulated natural selection.
Remind students of the definition of natural selection.

a. The environment selects for certain traits. Creatures that had these advantageous traits would survive and reproduce.

Ask the students which of the creatures do they think will be best suited to survive in the future. According to natural selection, the creatures whose traits are selected for in the environment will pass their traits on.

Ask the following questions to the class to conclude the lesson:

a. What is a trait? *Answer: Traits are mostly physical characteristics or features that you have, which can differ between people*
b. By what is a trait influenced? *Answer: Genes and environment*
c. What is natural selection? *Answer: The process by which an organism's traits are passed on or selected based on their environment*
d. How does natural selection work? *Answer: Variations in a trait that allow an organism to survive better are passed down to the organism's offspring*
e. How does environment influence survival? *Answer: Organisms with traits that help them survive in an environment are selected for, and organisms with traits that do not help them survive in an environment are selected against*
f. What is an adaptation? *Answer: A trait that helps an organism survive in a specific environment*

Lesson written by:
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Leandra Fernandez, Undergraduate Lab Assistant for VSVS, Vanderbilt University
Jason Wong, Undergraduate Lab Assistant for VSVS, Vanderbilt Universiy

Observation Sheet

Circle the Traits your creature has.

Trait	Variation 1	Variation 2	Variation 3
Leg Length	Short	Long	
Wings	Absent	Present	
Foot Shape	Webbed	Talon	
Tail Length	Short	Long	
Arm Length	Short	Long	
Antenna Shape	Knob	Star	
Antenna Length	Short	Long	
Beak Shape	Trumpet	Crusher	
"Hand" Shape	Claw	Paw	
Ear Shape	Mouse	Elephant	
Skin Color	Red	Purple	Blue
Eye Color	Red	Green	Stop-and-Go

Tally Chart

For each scenario, give a +1 or -1 in the tally box for the appropriate trait. At the end add up the net score.

Trait	Variation	Tally	Net Score
Leg Length	*Long*		
	Short		
Wings	*Wings*		
	No Wings		
Foot Shape	*Talon*		
	Webbed		
Tail Length	*Short*		
	Long		
Arm Length	*Short*		
	Long		
"Hand" Shape	*Claw*		
	Paw		
Antenna Shape	*Star*		
	Knob		
Antenna Length	*Short*		
	Long		
Beak Shape	*Crusher*		
	Trumpet		
Ear Shape	*Mouse*		
	Elephant		
Skin Color	*Red*		
	Blue		
	Purple		
Eye Color	*Red*		
	Green		
	Red and Green		

VANDERBILT STUDENT VOLUNTEERS FOR SCIENCE
http://studentorg.vanderbilt.edu/vsvs

Chromatography

Goal: To demonstrate a technique or process for separating mixtures that is used by biologists, chemists, clinical scientists, and forensic scientists (detectives).
Tn State Stds: 5PS1.4

Lesson Outline
I. A. What is a Mixture?
Explain to the students that there are 2 types of mixtures – homogeneous and heterogeneous. And show examples of both.
Discuss methods used to separate mixtures.
B. Making a Homogeneous Mixture
Explain to the students that chromatography is a process for separating mixtures. In today's lesson, paper chromatography will be used to separate water-soluble inks into their different colors, starting with the separation of green into blue and yellow.
II. Chromatography Using a Green Pen to separate a Homogeneous Mixture
Show students the proper procedure for setting up a chromatography experiment, using a 16 oz cup, a stick, green pen, and a paper strip. Each student pair will do this.
III. Forensic Chromatography
Each pair does a chromatogram of one of the four pens to help determine which pen was used to write a ransom note. After the chromatograms are finished, ask the students to compare their chromatograms with the chromatogram prepared from the guilty person's pen to determine who is the guilty person.
IV. Review

Materials
3 250 mL bottles filled with water (use to put water to the mark (about 25-30 mL) into the 16-oz cups)
1 bag of colored balls
1 jar sand and iron filings and cow magnet
1 bag containing 1 125cc jar of blue water, 1 125cc jar yellow water (1/4 filled)
1 bag containing: 16 rolls of clear tape
1 bag containing 16 wooden sticks
1 bag containing 5 green pens
1 bag containing 16chromatography strips with green horizontal line drawn 2 cm from the bottom of the strip
1 bag containing 16chromatography strips (horizontal pencil line is drawn 2 cm from the bottom of the strip)
16 16 oz. clear plastic cups, marked at the 25 - 30 mL level
1 large bag containing 15 black pens labeled with suspects initials (PC, PS, JF or MM)
16 prepared laminated chromatograms from the "guilty" person's pen (PC)
16 prepared laminated chromatograms from the 4 different pens
16 sheets of paper towel

SET UPS FOR LESSON:
While a VSVS member does the Mixing Colors demonstration:
1. Another member pours water into enough 16 oz cups to the marked level for pairs in the class, plus one for VSVSers to do demonstration
2. Remaining members will attach the **chromatography paper already marked with the green pen to the sticks (see instructions on how to do this).**
   Hold the paper strip so that the top edge of the paper is even with the top edge of the wooden

stick.
Tear a small piece of tape and tape the paper strip to the wooden stick so that the tape goes around the stick and is taped to both the front and the back of the paper strip.

Put the following vocabulary words on the board:
Mixture, chromatography, chromatogram, capillary action, forensic chromatography

Unpacking the kit:

1. What is a Mixture?
1 bag of colored balls,
1 8 oz jar with sand/iron filings mixture and a cow magnet

B. Demonstration – Making a Homogeneous Mixture
1 bag containing: 1 jar blue water, 1 jar yellow water (each about ¼ filled)

II. Using Chromatography to Separate a Homogeneous Mixture (using a green Pen)
Materials: (1 set is for VSVS to use as demo)
16 16 oz. clear plastic cup with water to the mark (about 30 mL.)
5 green pens
16 chromatography strips that already have the green pen trace don the horizontal line AND prepared by VSVSers so that the paper is already attached to wood stick

II.Forensic Chromatography
Distribute the following materials to each **pair:**
1 piece of chromatography paper
1 16 oz clear plastic cup –students already have
1 stick – students already have, but the green chromatogram needs to be removed.
1 roll of clear tape
1 paper towel
Student pairs will need to share the black pens and tape
Distribute the 16 laminated chromatograms

1. What is a Mixture?

- **Mixtures** are made up of **two or more different elements or compounds** which can be separated by physical means.
  - Show students the bag of mixed balls. Explain that each differently colored ball represents an element or compound.
    - The balls are not connected, so they are a mixture.
    - Examples of mixtures include salt in water, air, soil, and sand. Mixtures can be made with any combination of phases of matter: solid in solid, (sand and iron filings), solid in liquid, (salt in water), gas in liquid (carbon dioxide bubbles in water) etc

- There are 2 types of mixtures: heterogeneous and homogeneous
  - In heterogeneous mixtures, the substances are unevenly mixed and you can see them.
  - In homogeneous mixtures, the different substances are evenly mixed so that you cannot see them. Mixing colored solutions is an example.

Your Notes

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A. Demonstration: Using the magnetic property of iron to separate a heterogeneous mixture.

Materials

1 8 oz jar with sand/iron filings mixture and a cow magnet

Tell students to look at the jar of sand.

- Why do you think it is a mixture? *Because it contains different kinds of particles*.
  - Tell the students that sand is a collection of fragments of minerals, shells, fossils and organic matter. Sometimes it contains iron in the form of magnetite, which is magnetic. This is called Ironsand and can be found worldwide.
- Ask students: Do you have any ideas how we can separate the iron from the sand? *With a magnet*. *Be sure to point out that the iron is magnetic and sand is not*. *Also be sure to mention that separation by magnetism is a physical means of separation*.

Emphasize that <u>a physical property</u> of iron can be used to separate the mixture.

- Tell students that you will use a cow magnet to separate the iron filings from the sand.
- The cow magnet will already be in the jar. Pull it out of the sand, and take it around the class to show the students the iron filings on it.

Share the following information with the students:

- Cow magnets are used by farmers to protect the cow's stomachs from being punctured by small pieces of baling wire or other bits of wire that cows might eat with hay.
- Cows have four stomachs. The cow magnet is placed in the first stomach to attract bits of wire in order to keep them from entering the other three stomachs.
- Farmers or veterinarians open a cow's mouth and place the cow magnet down its throat into the first stomach.
- Cow magnets are available from farm supply stores, farmer's co-ops and science supply stores.

B. Demonstration – Making a Homogeneous Mixture

Materials

1 bag containing: 1 jar blue water, 1 jar yellow water (each about ¼ filled)

Hold the jars up so the students can see them.

Ask the students: *What color do you get when you mix blue and yellow?*

Ask: "*What will happen if you combine the 2 liquids?* Accept responses.

Pour the blue liquid the yellow liquid together and show students that the mixing of the blue and yellow liquids makes a green liquid.

Ask students: Is this a homogeneous mixture? Why? *The blue and yellow liquids cannot be seen anymore.*

Did a chemical change happen? Or a physical change? (*Physical).*

II. Using Chromatography to Separate a Homogeneous Mixture (using a green Pen)

Materials: (1 set is for VSVS to use as demo)

16 16 oz. clear plastic cup with water to the mark (about 30 mL.)

Your Notes

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5 green pens
16 chromatography strips that already have the green pen trace don the horizontal line, paper is already attached to wood stick

Ask students: What colors mixed together result in green? *blue and yellow*
Show the students the green pen and tell them that the green is a *mixture* of blue and yellow inks.

Explaining: What is Chromatography?

Explain to the students that chromatography is a physical way to **separate mixtures**.
In today's lesson, paper chromatography will be used to separate water-soluble inks into their different colors, starting with a green pen and then a black pen to help solve a crime.

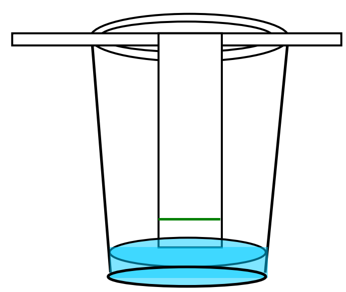
Show students:

- How the green pen was used to trace over the pencil line on the paper.
- How was the paper attached to the stick: hold the paper strip so that the top edge of the paper is even with the top edge of the wooden stick   Tear a small piece of tape and tape the paper strip to the wooden stick so that the tape goes around the stick and is taped to both the front and the back of the paper strip.
- Take one of the 16 oz cups that contains 30 mL of water and gently place the stick across the 16 oz. cup so the stick and paper will not fall into the cup. The strip should hang free in the center of the cup without touching the sides.
- The bottom of the paper should be in the water, BUT make sure the **green line does not** touch the water

PASS MATERIALS OUT TO PAIRS OF STUDENTS

- Each VSVS member will help students do this experiment
- As the water starts to go up the paper strip, show the strip to the students and tell them that this **capillary action** will help separate the colors.

Explanation:
Liquids can climb up paper, string, and other substances through the process of **capillary action**. The liquid moves upward through small pores, or capillaries, that are found in paper towels, filter paper, chromatography paper, and other porous materials; this is what makes these materials absorbent.   Scientists use this process to separate mixtures, including colors.



Background – Adapt to your class.
The paper is the **support** in this experiment. The **solvent** used (water in this case) has different degrees of absorption to the support. The greater the porosity of the paper, the better the capillary action or wicking, and the faster the water will climb. As the water moves up the paper strip, it dissolves the water-soluble pigments of the green pen mark. Each pigment travels at a different speed depending on its solubility in water and its absorption on the paper. The color separation is called developing a **chromatogram** (a color pattern)**.** Chromatograms can be used to match and identify substances in biology, chemistry and forensic labs.
A simpler explanation is that the solvent carries the pigment farther if the pigment is more water soluble.

Your Notes

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III. Forensic Chromatography

Tell students that:

- Chromatography is used in crime labs to separate components of "clue" substances such as blood, ink, or other mixtures found at the scene of the crime.
- Forensic scientists or detectives can also use the process of chromatography in their work.
  - The same pen will always show an identical pattern of separation into its separate colors. This is because pens include a specific ink that has a specific mixture of pigments.
  - This illustrates how scientists can use chromatography for analysis.
- Chromatography can be used to identify the pen that was used to write a ransom note.

Read or tell the following scenario to students and tell them they will use chromatography to determine "Whodunit"!

NOTE: - You can change the scenario, BUT you cannot make it gory, have anything to do with sexual stories, or upsetting to young 5th graders.

The police (represented by Sam Suede, a hard-boiled police detective) have been called to the scene of a crime. The scene is a chemistry laboratory, and a small vial of Solution X has been stolen. A ransom note has been received, written in black ink, demanding one million dollars for the return of Solution X. Through questioning, Sam Suede learns that rumors have been spreading that Solution X may be the long-awaited cure for the common cold!

Sam discovers that there are four prime suspects who all have a motive for committing this crime. They are as follows:

- Pam Chromatogram (Pen PC)
- Mary Masonite (Pen MM)
- Patrick Street (Pen PS)
- John Fingerprint (Pen JF)

Sam has obtained a pen from each of these suspects and has a chromatogram that was made from the ransom note. Sam needs your help in matching the suspect's pen to the ransom note.

Distribute the following materials to each **pair:**

- 1 piece of chromatography paper
- 1 16 oz clear plastic cup –students already have
- 1 stick – students already have, but the green chromatogram needs to be removed.
- 1 roll of clear tape
- 1 paper towel
- 1 black pen - student pairs will need to share the black pens and tape

Each pair will follow the procedure demonstrated in Part II to obtain a chromatogram of one of the suspect's pens.

Have each of the students do the following:

- Trace the pencil line with their black pen.
- Tell each student to mark the top of the chromatography paper near the stick with the initials on their pen (PC, PS, JF, or MM) **with a pencil**.
  - Hold up a stick with a piece of chromatography paper taped to it to make sure the students know where to place the initials – **at the top near the stick**.
- Take the 16 oz cup that contains 30 mL of water and gently place the stick across it so the stick and paper will not fall into the cup. The strip should hang free in the center of the cup without touching the sides.
- Wait about five or six minutes for development of the chromatogram.

Your Notes

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After the chromatogram has developed enough so that the different colors can be identified, tell the students to:

- Lift the stick out of the cup and remove the chromatogram from the stick by holding the paper near the taped end and sliding it off the stick.
- Place the chromatogram on a sheet of paper towel.

Ask 4 students to describe the 4 different chromatograms. The results can be put on the board, or shown to the class. **Emphasize that each pen has a unique chromatogram.**

Distribute the 16 laminated chromatograms prepared from the guilty person's pen and ask them to compare it to their chromatogram. Identify which pen matches the results from the ransom note.

Ask students: Who is the guilty person? *PC - Pam Chromatogram*

IV. **Review of chromatography**

Adapt to your class:
In most of the variations of chromatography, a substance (ink dot, candy coating, leaf extract) is placed onto a support (paper strip). A solvent (water, alcohol) is then added, which moves up the support because of capillary action. As the solvent moves through the test substance, some of the test substance is dissolved in the solvent and carried up the support. Different types of substances move different distances, which depend on their differences of solubility in the solvent and their absorption on the paper. As a result, separation occurs. This is always constant for a particular support and solvent. Chromatograms of these substances are then compared with known chromatograms to identify the substances.

REVIEW QUESTIONS

1. Why does water move up the paper strip?
   Answer: capillary action
2. In the separation of the green ink, the blue pigment moves higher (faster) than yellow pigment. Why?
   Answer: The speed of movement of a component of a mixture, in this case colors, depends on its relative solubility in the solvent (water) and its relative strength of attachment (absorption) to the paper. The blue pigment is more soluble (more attracted to water than to the paper) and less absorbent (less attracted to the paper) so it moves faster up the paper strip.

References
1. M. Sarquis and J. Sarquis, Eds., ***Fun with Chemistry***, Vol. 2, pp. 3-8.
2. J. Barer, ***Crime Lab Chemistry***, Teacher's Guide: Lawrence Hall of Science, University of California, Berkeley, CA.
3. D. R. Kimbrough, ***J. Chem. Educ***., Vol. 69, p. 987, December, 1992.

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Your Notes

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Chromatography Observation sheet

Name:________________________

Chromatography Part I: Separation of Green Colors

1. What did the color change to when the yellow and blue solutions were mixed?

   ____

2. What happened to the marker's green color on the chromatography paper.

   ____

3. What can you conclude about the green ink? How many dyes are used to give it its color?

   ____

4. Which color traveled faster?

   ____

Chromatography Part II: Forensics Using Black Pens

5. Draw and label your results on the "chromatography paper" below. Include the initials of the suspect's pen on the diagram.

6. Is your chromatogram the same as those from other black pens?

   ____

7. Whose pen was used to write the ransom note?

   ____

Answers Chromatography Observation sheet

Name:________________________

Chromatography Part I: Separation of Green Colors

1. What did the color change to when the yellow and blue solutions were mixed?
   ______green__________________________________

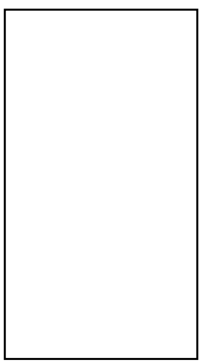
2. What happened to the marker's green color on the chromatography paper.
   ______________separated into yellow and blue_____

3. What can you conclude about the green ink? How many dyes are used to give it its color?
   ___2 dyes____________________________________

4. Which color traveled faster?
   _____blue_________________________________

Chromatography Part II: Forensics Using Black Pens

5. Draw and label your results on the "chromatography paper" below. Include the initials of the suspect's pen on the diagram.



6. Is your chromatogram the same as those from other black pens?
   ________not all________________________________

7. Whose pen was used to write the ransom note?
   _________PC – Pam Chromatogram_______________

VANDERBILT STUDENT VOLUNTEERS FOR SCIENCE

Diffusion

Goal: To understand diffusion, the process in which there is movement of a substance from an area of high concentration of that substance to an area of low concentration

TN Curriculum Alignment: 7.LS1.2

VSVSer **Lesson Outline**

_______ **I. Introduction**

Discuss the motion of molecules using examples such as the smell of cooking from a distance or the smell of perfume in the air when someone wearing perfume walks by.

_______ **A. Modeling Semi-Permeable Membranes**

One VSVS member will show students how to use a container with a wire-screen separating rye seeds and bean seeds as a model for a semi-permeable membrane. The rye seeds, representing small molecules, pass through the screen but the bean seeds, representing large molecules, do not pass through the screen.

_______ **B. Dialysis tubing and Relative Sizes of Molecules**

Show students the paper models of iodine, glucose, and starch. Discuss the relative sizes and point out that starch is a "polymer" molecule made up of hundreds of glucose molecules joined together.

_______ **II. Testing for Glucose and Starch**

A. Glucose Test

Student use glucose test strips to become familiar with the positive test for glucose.

_______ **B. Starch Test**

Students use iodine to test for starch.

_______ **III. Diffusion of Glucose and Starch**

A. Glucose Diffusion

A VSVS volunteer should distribute the dialysis tubing (containing glucose and starch) in the cup to each pair of students.

_______ **B. Predicting Which Molecules Will Diffuse**

While students are waiting, show them the paper models of the molecules again and have the students try to predict which molecules will diffuse through the tubing.

_______ **C. Testing for Diffusion of Glucose**

Groups test for glucose after 10 minutes.

_______ **D. Testing for Diffusion of Starch**

After a positive test for glucose outside the dialysis tubing has been obtained, students can add **ALL** the rest of the iodine to the water in the cup. Students should observe a purple/black color form inside the dialysis tubing.

_______ **IV. Review**

Summarize the glucose and starch dialysis results for the whole class. As part of this review, show the models of iodine, glucose, and starch to make sure students understand the relationship of molecular size to their ability to diffuse through semi-permeable membranes.

LOOK AT THE VIDEO BEFORE YOU GO OUT TO YOUR CLASSROOM
https://studentorg.vanderbilt.edu/vsvs/lessons/
USE THE PPT AND VIDEO TO VISUALIZE THE MATERIALS USED IN EACH SECTION.

Notes on solutions used:
The glucose solution is made to be 30%. The starch solution is made from soluble starch (a "handful" of starch "peanuts" in 1 L. water plus 1 tsp cornstarch. The solution mixture inside the dialysis tubing is 80% glucose/20% starch.

1. Before the lesson:
In the car ride, read through this quiz together as a team. Make sure each team member has read the lesson and has a fundamental understanding of the material.

1. What is diffusion?
2. What is a semi-permeable membrane, and what is the relationship between molecular size and ability to diffuse through a semi-permeable membrane?
3. Which molecule(s) is/are permeable through the dialysis tubing? Which is/are impermeable?
4. Which molecule is a polymer?
5. How can the presence of glucose be detected? How can the presence of starch be detected?

2. During the Lesson:
Here are some Fun Facts for the lesson – for VSVS members
Diffusion is a passive process, meaning that it occurs spontaneously, without the input of energy.
The rate of diffusion is affected by size of molecule, steepness of concentration gradient, and temperature (related to the speed at which the molecules are moving).
Examples of diffusion in everyday life: the contents of a teabag diffuse into hot water, helium diffuses out of a balloon causing it to deflate, the smell of warm cookies diffuses throughout a room
Water, oxygen, carbon dioxide, and various other essential molecules are constantly diffusing across the membranes of our cells.
The diffusion of water is called osmosis. Water molecules move across a membrane trying to achieve equilibrium. Example: a carrot placed overnight in fresh water will swell; a carrot placed in salt water will shrivel.

Set-Up
VSVS members do this while one member starts Introduction
Materials needed for set-up for 16 pairs:
16 6-oz plastic cups
16 pieces of dialysis tubing containing the glucose and starch mixture.
16 plastic plates
32 1oz cups water
Count the number of students and remove enough dialysis tubes for each pair. Place the dialysis tubes into individual 6oz cups and place each cup on a plate. Pour enough water into the cup so that the water JUST covers the tubing. **Set aside – do not give to students until Part III.**

- Take 32 1-oz cups and pour a little water in the bottom of each cup. Save for Section II.

Unpacking the Kit – what you will need for each part
While one team member starts the introduction, another should write the following vocabulary words on the board:
diffusion, osmosis, dialysis tubing, glucose, starch, iodine, semi-permeable membrane
Refer to vocabulary words throughout the lesson when you encounter them.

Your Notes:

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For Part IA: Introduction.

16 clear plastic containers with wire screen and seeds, 32 Observation Sheets

For Part IB: Relative Sizes of Molecules

1 dialysis tube containing glucose and starch
1 set of laminated paper models of iodine, glucose, and starch

For Part II: Testing for Glucose and Starch

For Part IIA. Glucose Test

16 Instruction Sheets, 16 plastic bags each containing 3 Glucose Test Strips (in a small bag) and 1 Glucose Test Results Chart (laminated), 16 1-oz bottles of 30% glucose, 16 1-oz cups of water, 16 tweezers

For Part IIB. Starch Test

Above materials plus additional materials:
16 1 oz. cups of water, 16 dropper bottles of iodine (in a protective plastic container), 16 oz containers of starch suspension (shake well)

For Part III: Diffusion of Glucose and Starch

IIIA Diffusion: 16 pieces of dialysis tubing placed in 6-oz plastic cups, (see set-up) 16 plastic plates,

III B: Predicting Which Molecules Will Diffuse

Paper models of the molecules from IB

For Part IIIC. Testing for Diffusion of Glucose

Glucose strips and tweezers from Part IIA

Part III D. Testing for Diffusion of Starch

Remaining iodine from Part IIB

I. Introduction

Learning Goals: Students define the term "semi-permeable membrane," give real-world examples, and demonstrate how they can be used to separate different-sized molecules

Note: Organize the students into pairs

- Discuss the motion of molecules using examples such as the smell of cooking from a distance or the smell of perfume in the air when someone wearing perfume walks by.
  - This happens because molecules are in constant motion and gas molecules (perfume, aroma of cooking) mix (diffuse) with the air in the vicinity.

A. Modeling Semi-permeable Membranes

Materials

16 16 oz. clear plastic containers with wire screen and seeds
32 Observation Sheets

- Ask students: What is a **semi-permeable membrane**?

Your Notes:

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- Include the following information in the discussion:
    - A **semi-permeable membrane** is a membrane in a cell that allows materials to pass into and out of a cell.
    - The openings in the membrane are large enough to allow some substances to move in and out of the cell, but are small enough to keep some substances from leaving or entering the cell.
- Give each **student** an observation sheet
- Give each **pair** one of the 16 oz. clear plastic containers with lids that contains a wire screen in the middle with rye seeds on one side and bean seeds on the other side. Rye and bean seeds are used to represent molecules of two different sizes. The wire grid screen represents a semi-permeable membrane (such as a cell membrane in plants or animals). The holes represent the pores or openings in the membrane.
- Ask one student to keep the container in view of all group members and shake the plastic container sideways, keeping the lid up and observe what happens.
- Ask students to explain what happened. .
    - The students should observe that the rye seeds can pass through the wire screen (both ways) but the bean seeds cannot.
    - After a few minutes, the levels of seeds will no longer be equal because the side with the bean seeds will have some of the rye seeds as well.

B. Dialysis tubing and Relative Sizes of Molecules

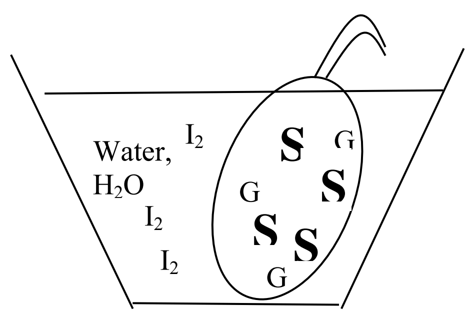
Materials:

1 dialysis tube containing glucose and starch
1 set of laminated paper models of iodine, glucose, and starch

- Show students the paper models of the three molecules, and tell them the names of the molecules. Do not discuss anything about these molecules except to tell them that the solutions they are using today contain these molecules.

- The VSVS instructor should hold up a dialysis tube with glucose and starch so that the class can see it.
    - Have the students observe that there are no fluids leaking out of the tubing.
    - Tell the students that the **dialysis tubing** is similar to a cell membrane, and that the students are going to discover which of the three molecules are small enough the pass through the tubing. Show the students the tubing in the prepared cups and point out the water just covering the tubing.

- Tell students to look at the diagram on the observation sheet and point out that the dialysis tubing contains starch and glucose molecules.
    - **Starch** molecules are represented by large **S's** and **glucose** molecules are represented by **G's.**
    - **Iodine** molecules, represented by **I_2's,** are shown outside the dialysis tubing because they will be added to the outer solution during the experiment.
    - **Water** is **H_2O**



Your Notes:

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- Tell students that they will work in pairs for the following experiments.

II. Testing for Glucose and Starch

Learning Goals: Students identify different indicators that can be used to systematically test for the presence of various molecules

Materials - distribute to each pair:
1 Instruction Sheet
1 plastic bag containing 3 Glucose Test Strips (in a small bag) and 1 Glucose Test Results Chart (laminated)
1 1-oz bottle of 30% glucose
1 1-oz cup of water
1 tweezer

Note: One VSVS volunteer will demonstrate the following procedure and will give the instructions; the other volunteers should monitor pairs to make sure procedures are being followed accurately and to give assistance as needed.
Students can refer to the instruction sheet as they are doing the experiments but you will still need to guide them through the procedures.

- Tell the students that they need to know how to prove which molecules have moved through the membrane. They need to know how to test for **glucose** and **starch**.

A. Glucose Test

- Ask students if they know about testing for glucose with glucose strips.
  - Diabetics use these strips to monitor their glucose levels.
- Tell the students to place the 1-oz cup of water and the 1-oz glucose bottle on the appropriate circles on the observation sheet.
  - Take the cap off of the 1-oz glucose bottle.

Tell students not to touch the glucose test strip with their fingers - use the tweezers.

- Dip one end of the test strip into the 1 oz. plastic bottle labeled glucose. Hold the strip above the bottle to remove any excess solution.
  - Place this strip in the rectangle on the paper (below the 1 oz bottle).
- Then test the water cup with another glucose test strip, following the same procedure.
  Wait a few minutes before checking the results.
- Tell students to compare the color of glucose test strips with the Glucose Results Color Chart, and record the values from the Glucose Results Color Chart on their observation sheets.
  - **Yellow** indicates **no glucose** and shades of **green** indicate the presence of **glucose**. The darker the shade of green, the more glucose is present.
  - Test strips dipped in glucose should be dark green indicating the presence of lots of glucose.
  - Test strips dipped in water should remain yellow.
- Use these strips to verify the final test results later in the lesson.

Note: The test strip dipped in water should be yellow indicating the absence of glucose. If anyone's strip did turn green, try to determine the reason the strip turned green. This could happen due to contamination if glucose was spilled in the water or if a student touched the pad of the strip after handling the glucose set-up.

- Tell students to replace cap on 1-oz bottle of glucose.

Your Notes:

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B. Starch Test

Distribute the following additional materials to each pair:

1 1 oz. cup to use for testing water
1 dropper bottle of iodine (in a protective plastic container)
1 1 oz container of starch suspension (shake well)

- Tell students to place the 1-oz cup of water and the 1-oz starch container on the appropriate circles on the observation sheet.
- They should shake the 1-oz starch container and then remove the cap.
- Tell students to add one squirt of iodine to both the 1 oz cup containing water and the 1-oz container of starch.
- Tell students to check for a color change and record the color, if any, on their observation sheet. *A dark purple/black color indicates the presence of starch in the starch container. The water cup should be a light orange/yellow or amber color which indicates the presence of iodine only.*
- Then have students put the cap back on the 1-oz starch container.

Tell the students they must not disturb the cup and the dialysis tubing.

Learning Goals:

- **Students identify different indicators that can be used to systematically test for the presence of various molecules**
- **Students identify different indicators that can be used to systematically test for the presence of various molecules**

III. Diffusion of Glucose and Starch

Materials:
Distribute the earlier prepared 6 oz. plastic cups containing a piece of dialysis tubing in water for each pair and plates.

A. Glucose Diffusion

Tell students that diffusion of glucose takes time, but it has already been happening while they have been discussing diffusion. They need to leave the dialysis tubing for another **10 minutes** to allow time for diffusion to occur. Go on with section B while students wait.

B. Predicting Which Molecules will Diffuse

Materials:
1 set of laminated paper models of iodine, glucose, and starch (paper models are stored in binder)

- Review the relative size of the molecules by showing the students the paper models of the three molecules again.
- Discuss the relative sizes of the molecules, pointing out that the results of today's activities will be dependent upon the different sizes of iodine, glucose, and starch molecules.
- Point out that starch is a "polymer" molecule made up of hundreds of glucose molecules joined together.
- Have the students refer back to their seed containers.
    - Tell the students that this is a good model for a semi-permeable membrane.

Your Notes:

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- The small rye seeds represent small molecules, such as water, iodine, or glucose that can pass through a porous membrane both ways while larger molecules cannot.
- The larger bean seeds represent large molecules such as starch molecules that cannot pass through the semi-permeable membrane.

- Ask the students if they can predict which way the different molecules will move.
  - The iodine is a small molecule and can move from the water outside the tubing, to inside it.
  - The starch is a large molecule and cannot get outside the tubing.
  - The glucose is small and should be able to move from inside the tubing to the water on the outside.
- Tell students that the molecules of substances have been diffusing in the experiments set up earlier in the lesson and it is time to check on these experiments and investigate what has been happening.
- Caution students to wait for instructions before they do the experiments.

C. Testing for Diffusion of Glucose

After the tubing has been in the water for about 10 minutes:

- Ask students to dip a clean glucose test strip into the water close to the dialysis tubing (it may even touch the tubing) and place the test strip on the appropriate rectangle of the observation sheet.
- While students are waiting for the results of this test, ask them what the results of the glucose test strip will tell them.
  - If the test strip remains yellow, then no glucose was able to pass through the dialysis tubing.
  - If the test strip turns green, then glucose was able to pass through the dialysis tubing.
- Ask students to check the glucose test strip, compare its color with the Glucose Results Color Chart, and record the value on their observation sheet.
- *The glucose test strip should turn green within 1 minute, indicating the presence of glucose in the water. This shows that glucose molecules have passed through the dialysis tubing. If it did not turn green, test again (close to the tube) after several more minutes have passed*
- Ask students to look at the plastic container of seeds. Ask them if this were a model of the glucose experiment, which seeds represent the glucose molecules.
  - *The small seeds are the glucose molecules because they could travel through the dialysis tubing.*
- Ask students to refer to the diagram on the observation sheet and use arrows to show the direction glucose molecules have moved.

D. Testing for Diffusion of Starch

> **Note:** This part MUST be done after a positive test for glucose has been obtained. **The glucose test strips will not work after iodine has been added to the water.**

- Have students unscrew the lid on the iodine bottles and add **all** the rest of the iodine to the water in the cup that is holding the dialysis tubing. The solution should be a light orange/yellow or amber color.

Note: If a positive test occurs when the iodine is added to the water around the dialysis tubing, the tubing has a leak. If this happens, empty their cup, rinse with water, and place a newly rinsed dialysis tubing in the cup and add iodine again. (Use the extra bottle of iodine that was provided.) If all else fails, have them observe the results of another group.

Your Notes:

___

___

___

- Ask students to observe the solution inside the dialysis tubing and the water surrounding it for a few minutes.
  - If they observe a color change, they should record it on their observation sheet.
  - *Students should observe a purple/black color inside the dialysis tubing*.
- Ask students what this purple/black color tells them.
  - The purple/black color indicates that iodine molecules have passed through the dialysis tubing and detected the presence of starch inside the dialysis tubing. Since the outside solution is not purple/black, starch molecules have not passed through the dialysis tubing into the water.
- Tell students to look at the plastic container of seeds.
  - Ask them if this were a model of the iodine and starch experiment, which seeds represent the iodine molecules and which represent the starch molecules.
  - The large seeds are the starch molecules because they could not get out of the dialysis tubing; the small seeds are the iodine molecules because they could travel through the dialysis tubing.
- Ask students to refer to the diagram on the observation sheet and use arrows to show the direction iodine molecules have moved.

IV. Review

Learning Goals:
- **Students define the term "semi-permeable membrane," give real-world examples, and demonstrate how they can be used to separate different-sized molecules**
- **Students identify different indicators that can be used to systematically test for the presence of various molecules**

Summarize the glucose and starch dialysis results for the whole class. Refer to diagram on observation sheet during review.

- Glucose gave a positive test in the water surrounding the dialysis tubing. Therefore, glucose molecules traveled through the dialysis tubing.
- The water in the cup remained yellow (the color of iodine), not the purple color found when starch is present. Therefore, starch molecules did not travel through the dialysis tubing into the water.
- However, there is a purple-black color inside the tubing. Therefore, iodine molecules traveled into the dialysis tubing and reacted with the starch molecules
- Show the molecule models of iodine, glucose, and starch to the students again to emphasize the relationship between molecular size and the ability to diffuse through a semi-permeable membrane like dialysis tubing.

Collect used dialysis tubing in a large ziploc bag or dispose of them at the school. Return all unused tubing.
Pour contents of water in all cups down the drain. Return all cups to lab in plastic garbage bag. Please do not let glucose solutions leak into lesson box – that makes for a very sticky mess to clean.
Return used 1-oz bottles of glucose and starch and all solution containers to the VSVS lab for re-use.

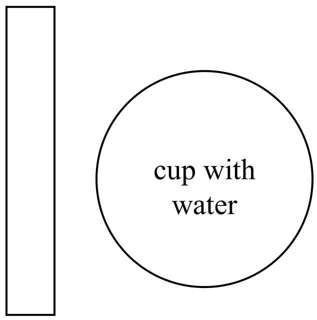
Reference for Part V: J. G. Morse and E. Vitz, "A Simple Demonstration Model of Osmosis," **J. Chem. Educ**., Vol. 76, pp. 64-65, January, 1999.
Lesson written by Pat Tellinghuisen, Coordinator of VSVS, Vanderbilt University
Dr. Melvin Joesten, Professor Emeritus, Chemistry Department, Vanderbilt University
Susan Clendenen, Teacher Consultant, Vanderbilt University
We gratefully acknowledge the assistance of Ann Orman and Kay Boone, MNPS teachers.

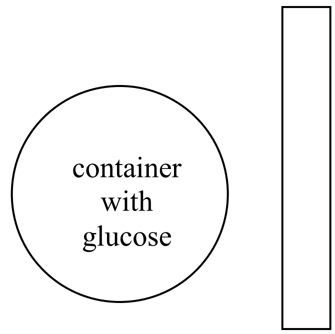
Your Notes:

Observation Sheet **Name** ________________________________

Vocabulary Words: diffusion, osmosis, dialysis tubing, glucose, starch, iodine, semi-permeable membrane

GLUCOSE TEST





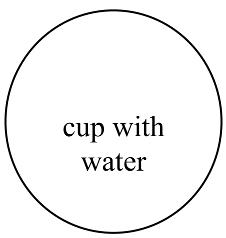
What color is the glucose strip after it is dipped in water?

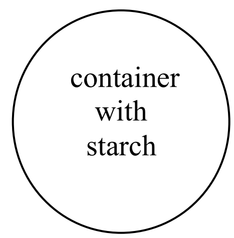
____

What color is the glucose strip after it is dipped in glucose solution?

____

STARCH TEST





What color is the water after iodine is added?

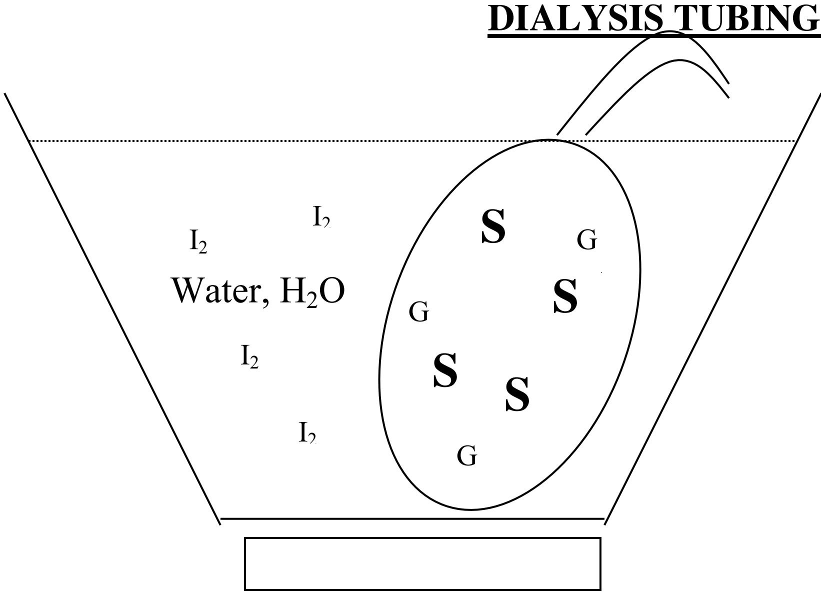
____

What color is the starch solution after iodine is added?

____

Predict the Direction of Movement of the Molecules:
Remembering what size beans crossed the wire screen, predict which molecules will diffuse in what direction in the experiment. Draw arrows next to a starch (S), glucose (G) and iodine (I_2) molecule in the cup diagram below, to show the predicted diffusion direction.

DIALYSIS TUBING TESTS



10 minutes after dialysis tubing is added to water: What is the color of the glucose strip when it is dipped into the liquid **closest to t**he tubing?

____

5 minutes after the iodine is added: What is the color of solution **inside** dialysis tubing

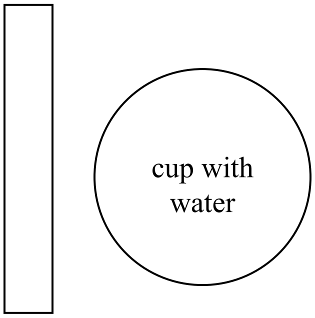
____

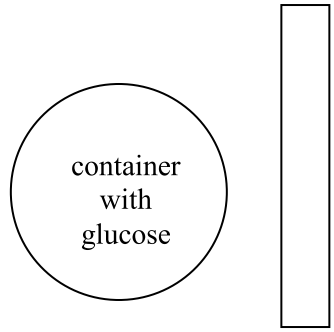
Were your predictions for the movement of the molecules correct?

Observation Sheet - Answers **Name** ________________________________

Vocabulary Words: diffusion, osmosis, dialysis tubing, glucose, starch, iodine, semi-permeable membrane

GLUCOSE TEST





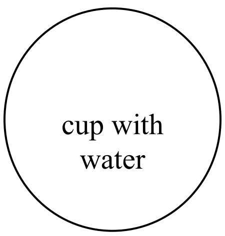
What color is the glucose strip after it is dipped in water?

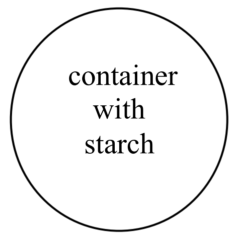
no color

What color is the glucose strip after it is dipped in glucose solution?

green

STARCH TEST





What color is the water after iodine is added?

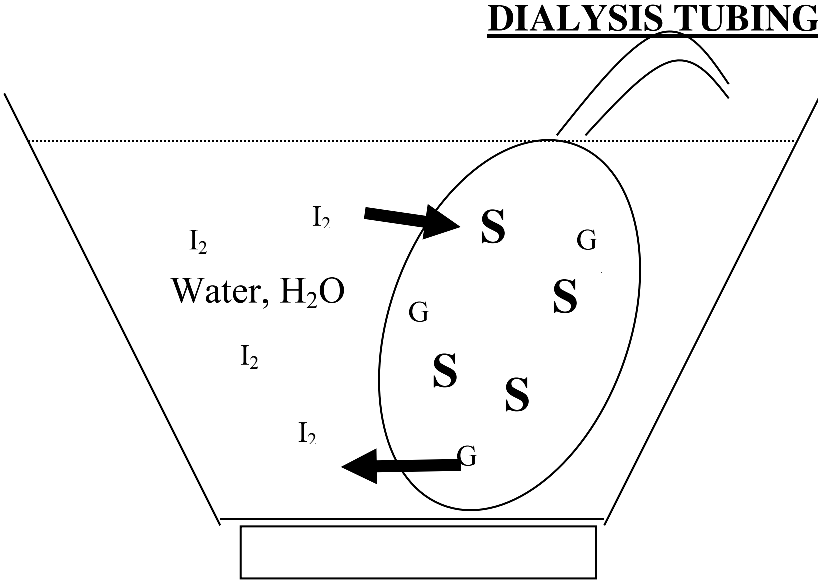
pale yellow – the color of dilute iodine

What color is the starch solution after iodine is added?

Blue/Black

Predict the Direction of Movement of the Molecules:
Remembering what size beans crossed the wire screen, predict which molecules will diffuse in what direction in the experiment. Draw arrows next to a starch (S), glucose (G) and iodine (I_2) molecule in the cup diagram below, to show the predicted diffusion direction.

DIALYSIS TUBING TESTS



10 minutes after dialysis tubing is added to water: What is the color of the glucose strip when it is dipped into the liquid **closest to t**he tubing?

____

5 minutes after the iodine is added: What is the color of solution **inside** dialysis tubing

____

Were your predictions for the movement of the molecules correct?

VANDERBILT STUDENT VOLUNTEERS FOR SCIENCE

Investigating Ionic, Covalent and Metallic Bonding

Acknowledgement: We want to thank NASA and the Tennessee Space Consortium for funds to purchase the Elenco Snap Circuit™ kits.

Goal: To measure the conductivity of solids and solutions using an LED in a circuit.
TN Curriculum Alignment: 7.PS1.5, 7.PS1.2

VSVSer Lesson Outline

________**I. Introduction to Bonding in Ionic, Molecular and Metallic Compounds.**
Students are introduced to ionic, molecular and metallic compounds
Explain Static and Current electricity. Write the vocabulary words on the board and explain conductors and nonconductors.

_______ **II. Explaining the Circuit – Demonstration**
Explain the circuit and LED and demonstrate how the students will use the red and black lead wires to test conductivity. Students discover that an electrical current will flow through a metal nail (which has metallic bonding) but not through a plastic cap.

_______ **III. Conductivity of Solutions of Ionic and Molecular Compounds**
Explain that some solutions conduct an electrical current. Students will test a number of solutions. Make sure they understand the importance of rinsing off the metal leads of the red and black wires in distilled water between each conductivity test.

_______ **IV. Using a Polymer to Distinguish Between Ionic and Molecular Compounds**
Students add ionic or molecular compounds to a gel of sodium polyacrylate and observe results.

a. Testing ionic and molecular compounds

_______**V. Review** Review the results of the lesson and the vocabulary words.

Materials

1 ea	Models of NaCl and water compounds
1	plastic bag containing a n assembled grid and nail and plastic bottle cap
16	sets of grids with assembled circuit
16	sets of instruction sheets
32	observation sheets
64	jars containing: salt, sodium bicarbonate, sugar and glucose
80	2oz cups
16	bags containing 4 taster spoons,1 chemwipe tissue, 4 toothpicks
16	100 mL bottles distilled water
16	10 oz cups
16	12 oz cups (the opaque ones)
2	containers sodium Polyacrylate
4	teaspoons
1	1L container of distilled water
16	Plates
16	6-well plates

1. In the car ride, read through this quiz together as a team. Make sure each team member has read the lesson and has a fundamental understanding of the material.

Lesson Quiz

1. What is the difference between static electricity and current electricity?
2. How can you tell the difference between a good conductor and a poor conductor through a conductivity test?
3. Will an ionic compound or a molecular compound conduct electricity when dissolved in water? Why?
4. Is sugar solution a conductor? Why?
5. At the conclusion of the lesson should the leads be snapped together before they are placed back in the kit? (NO)

Do not hand out materials until you have discussed the following background information.

Unpacking the Kit – What you will need for each section:

For Part I. Introduction

While one person is giving the Introduction, another VSVS member writes the following vocabulary words on the board**: ionic compounds, ionic bonds, molecular compounds, covalent bonds, conductors, insulators.**

Other VSVSers count the number of students in the class and put 1 tsp sodium polyacrylate into a 12 oz cup (the opaque one) and 200mL water into 10 oz cups

For Part II. Explaining the Circuit – Demonstration

1 grid with assembled circuit, plus a bag with a nail and a bottle cap for demonstrating conductivity.

For Part III. Conductivity of Solutions

Materials for each pair: 1 grids with assembled circuit, 1 instruction sheets , 2 observation sheets
4 jars containing: salt , sodium bicarbonate, sugar and glucose,5 2oz cups, 1 bag containing
4 tasterspoons,1 chemwipe tissue, 4 toothpicks, water bottle,

For Part IV. Using a Polymer to Distinguish Between Ionic and Molecular Compounds

Materials for each pair: 1 10 oz cup containing 1tsp sodium Polyacrylate, 1 10 oz cup containing 200 ml water, 1 teaspoon
1 Plate, 1 6-well plates
4 jars containing: salt , sodium bicarbonate, sugar and glucose5 2oz cups, 1 bag containing
4 tasterspoons,1 chemwipe tissue, 4 toothpicks from Part III

For Part V. Experiment - Investigating the Effect of Adding Ionic and Molecular Compounds to Sodium Polyacrylate

1. Introduction to Bonding in Ionic and Molecular Compounds and Metals

Materials: Models of ionic NaCl, and molecular water H_2O

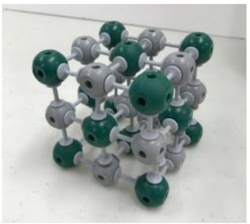
While one person is giving the Introduction, another VSVS member writes the following vocabulary words on the board**: ionic compounds, ionic bonds, molecular compounds, covalent bonds, conductors, insulators.**

Note: This section is meant to be a refresher of material they have already learned in class. It is more important that you get to the experimental parts.

Ask students: What are the different types of bonding that can form between atoms?

Answer: ionic, covalent or metallic

1. **Ionic Compounds**:

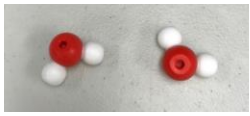


Show students the model of sodium chloride and explain that the sodium chloride crystal has a repeating pattern of equal numbers of Na^+ and Cl^- ions in 3 dimensions. This is called a crystal lattice.

An **<u>ionic compound</u>** forms between positive and negative ions that are created when atoms either **lose or gain electrons.**

Some ions are formed from single atoms, such as the sodium and chloride ions in salt (sodium chloride). Some ions are made of more than one atom, such as the bicarbonate ion (HCO_3^-) in sodium bicarbonate ($NaHCO_3$).

2. **Molecular Compounds:**



Show students the plastic bag containing the water molecules. The hydrogen and oxygen molecules are covalently bonded.

A **<u>molecular compound</u>** is made up of atoms that are **<u>covalently</u>** bonded. Covalent bonds are formed when atoms **share electrons**.

3. **Metals** easily lose valence electrons and become metal ions.
   a. Metallic bonds, like covalent bonds, also involve sharing electrons.
   b. But in metals, the electrons are shared over millions of atoms, while in molecular compounds, the electrons are shared between just 2 or 3 atoms.
   c. For example, in a covalently bonded compound like oxygen (O_2), electrons are shared between the 2 oxygen atoms; however, in a metallically bonded compound like a gold bar, electrons are shared over all gold atoms in that bar.

You might hear metallic bonding referred to as a 'sea of electrons' for this reason.

One of the differences in properties between ionic and covalent compounds is the ability to conduct an electrical current when they are added to water.

Most metals, unlike either ionic or covalent compounds, conduct electricity as **solids** and don't need to be dissolved in water.

Tell students that they are going to conduct an experiment to determine if a compound is ionic or covalent.

Why is the science in this lesson important?

- In the food service/production industry, cooking equipment may be sanitized with harsh chemicals that have high concentrations of ions. A conductivity test can be used to determine if the cleaning agent has been sufficiently rinsed away. If there is still significant conductivity when pure water is in contact with the equipment, then the equipment should be further rinsed to remove the cleaning agent.
- Public water facilities often monitor the conductivity of their output water to determine how much material is dissolved in the water (total dissolved solids). It is important to note that this test only accounts for the dissolved solids that are conductive. However, this method would be useful to determine if water has been demineralized, that is, if hard water has been effectively treated to remove some of the contaminating ions. As another example, conductivity tests can be used to determine if desalination processes have removed all of the salt from ocean water so that it becomes fit for human consumption.

II. Explaining the Circuit

Learning Goals: Students define static and current electricity and observe that metallic compounds conduct electricity and molecular compounds do not.

Materials

1 grid with assembled circuit, plus a bag with a nail and a plastic bottle cap for demonstrating conductivity.

Ask students if they know what the 2 types of electricity are.

1. Static electricity is the build-up of electrical charge. It does not flow. Lightning is an example of static electricity being "discharged" after having been built up.

2. Current electricity is moving electrical charge, usually electrons. Some materials have more "free" electrons than others. Current electricity flows through a completed circuit.

Demonstration

Materials per pair

1 set of grids with assembled circuit
1 set of instruction sheets
2 observation sheets

Learning Goals: Students learn what an LED is, and understand how it is used to show that a circuit is complete.

VSVS team members should hold up the demonstration circuit to show the students.
Tell the students to look at **Diagram 1and their circuit board**.
Point out the different parts – batteries, circuit connectors, black and red leads, resistor and LED light.
Point out that a "lead" is a wire wrapped in an insulator.

Explain LED's to the students: LED's (Light Emitting Diodes) are more sensitive than light bulbs and glow brightly with small currents.

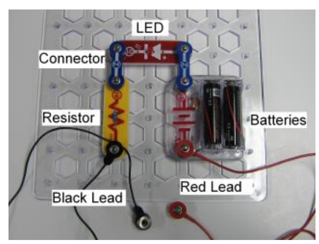


Diagram 1

VSVS information only: LED's are made from semiconductors. They can be damaged by high currents and so are used with resistors to limit the current. Do NOT allow the students to remove the resistor.

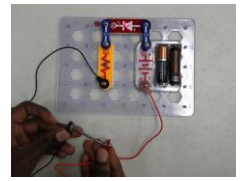
Ask the students what you should do to make the LED glow. *Touch the black and red lead together to complete the circuit*.
Show the students that this is correct and that the LED emits light. **Tell the students that the circuit is closed when the red and black leads are touching.**

Electrical current can flow through LEDs in one direction only. Show the students the direction of flow.

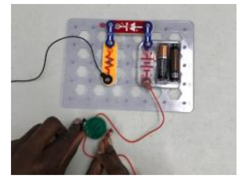
Current flows from the positive end ("knob") of the battery to the negative ("flat") end.

Tell the students that electricity flows through some materials better than others.

- **Conductors** are materials that allow the movement of electrons through them. Metals have many "free" electrons that can easily move, and therefore are *good* conductors. "Free" electrons are those not strongly held by the atom's nucleus. Since they are not strongly held, they are able to "jump" from one atom to another.



Now touch the end of one lead wire to the head of the nail and the end of the other lead to the point of the nail. The LED again lights up indicating that the circuit is closed. The metal nail is a *good* conductor of electricity and completes the circuit. **Remember that metallic bonding involves a "sea of electrons" that allows electrical currents to flow.**



Repeat with the bottle cap, putting the ends of the leads on opposite sides of the bottle cap. The LED will not light up, indicating the plastic bottle cap is not a conductor. Plastic bottle tops are made from molecular compounds, which have covalent bonds.

III. Conductivity of Solutions of Ionic and Molecular

Learning Goals: Students understand that solutions of ionic solutions conduct electricity and solutions of molecular compounds do not.

compounds

Materials per pair

16	sets of grids with assembled circuit
16	sets of instruction sheets
32	observation sheets
16	sets of jars containing: salt , sodium bicarbonate, sugar and glucose solids
80	2oz cups
16	bags containing 4 taster spoons,1 chemwipe tissue, 4 toothpicks
16	500 mL water bottles (containing distilled water)

Background information for VSVS members only (electrolytes and non-electrolytes are not in the 7th grade vocabulary):
Conducting liquids are called **electrolytes.** An **electrolyte** contains electrically charged ions that can conduct electricity. Some examples of electrolytic solutions are acids and bases and salt solutions such as sodium chloride (table salt) in water.
A **non-electrolyte** does not allow the flow of electric current because it does not have electrically charged ions that can conduct electricity. Some examples of non-electrolytic solutions are distilled water, sugar water.
Electrolytes are important to humans because they are necessary for proper cellular function, muscle function, and neurological function. A greater level of electrolytes is needed during strenuous muscular activity because more electrolytes are lost due to increased sweating. This is the reason why Gatorade and other sports drinks advertise that they replenish electrolytes.

Hand out the jars of solids to each group.
Tell the students to follow the instruction sheet and to record their results.

Tell students to:

- Rinse the metal ends of the black and red lead wires by dipping them into the cup of distilled water. Tell the students they will need to do this in between each test, to avoid contaminating the next test sample with the one just tested (make sure that the students know what contamination means).

- Place the 5 2oz cups containing distilled water on top of the diagram on the instruction sheet.
- Place the corresponding jar of solid next to the cup. Make sure that the students have the order correct. **Students must remove only ONE lid at a time, and replace it after pairs have tested the liquid.**
- Students **MUST** test the solutions in the order given, 1-5
  - The non-conducting solutions are tested first, followed by conducting solutions. This will help avoid contamination of the solutions.

1. Testing distilled water:

Put the metal ends of both lead wires in the cup containing distilled water, as far apart as possible, and note if the LED is glowing. (It should not). Remove the leads.

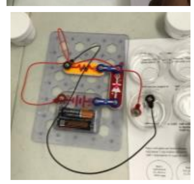
2. Testing water plus sucrose (sugar):

Remove the lid of the 1st jar (sugar) and add 1 mini spoon to the water. Stir with a toothpick, and then snap the toothpick in half so it cannot be used again. Repeat the conductivity test. Record your results. Replace the lid on the jar. The LED should not glow.
Rinse the metal ends of the wires in the distilled water jar..

3. Testing water plus glucose:

Remove the lid of the 2nd jar (glucose). Repeat the conductivity test. Record your results. Replace the lid. The LED should not glow.
Rinse the metal ends of the wires in the rinse cup.

4. Testing water plus sodium chloride (salt):



Remove the lid of jar 3 (salt).
Repeat the conductivity test Replace the lid. Record your results.
The LED should glow.
Rinse the metal ends of the wires in the rinse cup.

5. Testing water plus sodium bicarbonate (baking soda):

Remove the lid of the 4th jar and repeat the conductivity test. Replace the lid. The LED should glow.
Record your results. Rinse the metal ends of the wires in the rinse cup

Ask students if they can explain the results.

1. **Distilled water** does not contain ions and thus does not conduct electrical currents. Distilled water is a molecular compound with covalent bonds. (Note that TAP water can conduct an electrical current because it can contain metal salts that are ionic.)
2. **Sugar molecules** and **glucose molecules** are molecular compounds that do not split up into ions in water, and so do not conduct electrical currents
3. **Solid salt** and **solid sodium bicarbonate** will not conduct electricity because the sodium, chloride and bicarbonate ions are not free to move around in the solid form. However, when they are dissolved in water, the units dissociate completely into ions, and so are conductors of an electric current.

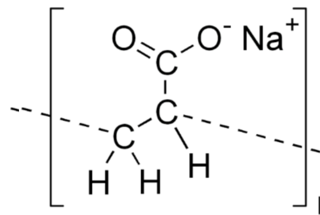
IV. Experiment: Using a Polymer to Determine if a Compound is Ionic or Molecular.

Materials:

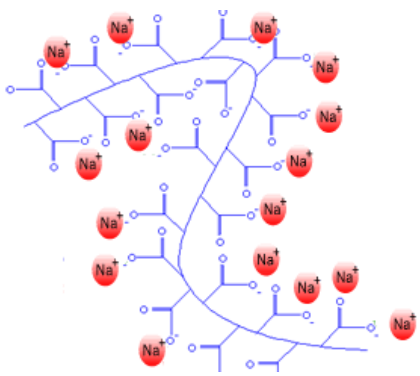
16	12 oz cups containing 1tsp sodium Polyacrylate
16	10 oz cups containing 200 ml water
2	containers sodium Polyacrylate
16	teaspoons
16	Plates

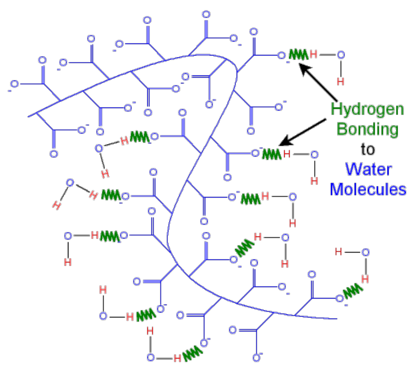
16 6-well plates
16 1oz jar of sugar, 1oz jar of glucose, 1oz jar of sodium chloride (salt), 1oz jar of sodium bicarbonate (baking soda),
16 bags containing 4 taster spoons, 1 chemwipe tissue, 4 toothpicks

Sodium Polyacrylate is a **superabsorbent polymer** found in disposable diapers and moisture absorbent for automobile and jet fuels. A superabsorbent polymer can absorb and retain extremely large amounts of liquid relative to its own mass]
This polymer absorbs about 300 times its weight of tap water (800 times its weight of distilled water because the ions in tap water reduce the absorbing properties of the polymer).



Note for VSVS members only: It is a polymer that consists of repeating units of the monomer. The picture is a single unit.
It is able to absorb large amounts of water because the sodium ions (Na^+) that are attached to it are replaced by water.
Point to the diagrams of sodium polyacrylate on their handout. Point out the Na^+ ions that are replaced by water molecules





Making a gel with sodium polyacrylate.

- Give each pair a (10 oz) cup containing the sodium polyacrylate and a 10 oz cup containing 200 mL tap water.

Tell them to:
1. Pour the water into the cup with the sodium polyacrylate and stir with a spoon.
   Observe that all the water is absorbed (forms a gel) immediately.

> VSVS Information only: Sodium polyacrylate will continue to absorb water until there is an equal concentration of water inside and outside the polymer. Each sodium polyacrylate molecule is able to attract and hold thousands of water molecules. Sodium polyacrylate, uses osmosis to soak up water. Because there is a higher concentration of water outside the sodium polyacrylate, it draws in the water through osmosis. Each sodium polyacrylate molecule is able to attract and hold thousands of water molecules.

V. Experiment – Investigating the Effect of Adding Ionic and Molecular Compounds to Sodium Polyacrylate

Fill each well with about 1 tsp of the gel.

a. Add 1 mini spoon sugar to well 1
b. Add 1 mini spoon glucose to well 2
c. Add 1 mini spoon sodium chloride (salt) to well 4
d. Add 1 mini spoon sodium bicarbonate (baking soda) to well 5

Observe what happens to the gel.

Either the gel collapses into a watery mess (for the ionic compounds) or it is not affected (for the molecular compounds).

Ask students: based on the previous experiment, which compounds are ionic or molecular?

Answers: Sugar and glucose are molecular.
Sodium Chloride and sodium bicarbonate are ionic.

Which compounds caused the gel to breakdown?

Answers: The ionic compounds
The solids that have no effect are the molecular compounds that are covalently bonded.

Explanation: The compounds that cause the breakdown contain a combination of metals and non-metals and are **ionic** compounds. Charged particles or ions from ionic compounds interfere with the stability of the polymer/water interactions in the gel. When sodium chloride and sodium bicarbonate are added to the hydrated polymer, the sodium ions from them attract the water. As a result, water molecules diffuse back out of the polymer. The addition of the salt breaks the "gel" polymer apart as water leaves the polymer to try to balance the water concentration inside and outside the polymer network

VI. Review

How can we distinguish between ionic and molecular compounds using an electrical circuit?
How can we distinguish between ionic and molecular compounds usingthe polymer sodium polyacrylate?
Go over the observation sheet with the students.

Lesson modifications by:
Dr. Mel Joesten, Emeritus Professor of Chemistry, Vanderbilt University
Pat Tellinghuisen, VSVS Director, Vanderbilt University

Conductivity Observation Sheet

Name ____________________________________

A. Testing the Circuit.
What happens when you touch the ends of the red and black lead wires together?

____

Explain____

B. Conductivity Tests with Solids
Which of the following materials cause the LED to light up?
Circle your answer.

1. iron nail	bright light
2 plastic bottle cap	no light

On this basis, what material has metallic bonding?
Which material is a molecular compound?

C. Conductivity Tests with Solutions
Which of the following solutions makes the LED glow brightly, dimly, or not at all?
Circle your answer.

1. distilled water	no light,	dim light,	bright light
2. sugar plus water	no light,	dim light,	bright light
3. glucose plus water	no light,	dim light,	bright light
4. sodium chloride plus water	no light,	dim light,	bright light
5. sodium bicarbonate plus water	no light,	dim light,	bright light

On the basis of the above results, which materials are ionic compounds?

____

Which materials are molecular compounds?

____

D. Testing the reaction of a polymer gel with ionic and covalent compounds
What happened to the polymer gel when the following were added?

1. Sucrose (sugar) ______________________________
2. Glucose ______________________________
3. Sodium chloride (table salt) ______________________________
4. Sodium bicarbonate (baking soda) ______________________________

On the basis of the above results, which materials "extract" water from the gel (the ionic or covalent compounds)?

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Conductivity Answer Sheet

A. Testing the Circuit.

1. What happens when you touch the ends of the jumper cables together?
   <u>The LED lights up.</u>

Explain: **<u>Touching the ends of the leads together completes the circuit.</u>**

B. Conductivity Tests with Solids

Which of the following materials cause the LED to light up?
Circle your answer.

1. iron nail	bright light
3. bottle cap	no light

On this basis, what material has metallic bonding? – iron nail
Which material is a molecular compound? Plastic cap

C. Conductivity Tests with Solutions

Which of the following solutions makes the LED glow brightly, dimly, or not at all?
Circle your answer.

1. distilled water	no light
2. sugar water	no light
3. glucose plus water	no light
4.. salt water	bright light
5. sodium bicarbonate plus water	dim light

On the basis of the above results, which materials are ionic compounds?

<u>Sodium chloride and sodium bicarbonate</u>

Which materials are molecular compounds

<u>distilled water, sugar and cornstarch</u>

D. Testing the reaction of a polymer gel with ionic and covalent compounds

What happened to the polymer gel when the following were added?

1.	Sucrose (sugar)	nothing
2.	Glucose	nothing
3.	Sodium chloride (salt)	gel becomes watery
4.	Sodium bicarbonate	gel becomes watery

On the basis of the above results, which materials "extract" water from the gel?

The ionic compounds, sodium chloride and sodium bicarbonate