8th Grade

Spring 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!

February						
SUN	MON	TUES	WED	THU	FRI	SAT
					1	2 New member training
3	4	5 New member training	6	7 Team leader training	8	9
10 Team leader training	11 Team training Lesson 1 / 5th-7th Alt training	12 Team training Lesson 1 / 5th/7th Alt training	13 Team training Lesson 1 / 5th/7th Alt training	14 Team training Lesson 1 / 5th/7th Alt training	15 Team training Lesson 1 / 5th/7th Alt training	16
17	18 Teams go out (Lesson 1) / Alt 6th-8th team training	19 Teams go out (Lesson 1) / Alt 6th-8th team training	20 Teams go out (Lesson 1) / Alt 6th-8th team training	21 Teams go out (Lesson 1) / Alt 6th-8th team training	22 Teams go out (Lesson 1) / Alt 6th-8th team training	23
24	25 5th-7th team training / Alt Teams go out (Lesson 1)	26 5th-7th team training / Alt Teams go out (Lesson 1)	27 5th-7th team training / Alt Teams go out (Lesson 1)	28 5th-7th team training / Alt Teams go out (Lesson 1)		

March						
SUN	MON	TUES	WED	THU	FRI	SAT
					1	2
3	4	5	6	7	8	9
10	11 6th-8th team training	12 6th-8th team training	13 6th-8th team training	14 6th-8th team training	15 6th-8th team training	16

17	18 Teams go out (Lesson 2)	19 Teams go out (Lesson 2)	20 Teams go out (Lesson 2)	21 Teams go out (Lesson 2)	22 Teams go out (Lesson 2)	23
24	25 Teams go out (Lesson 3)	26 Teams go out (Lesson 3)	27 Teams go out (Lesson 3)	28 Teams go out (Lesson 3)	29 Teams go out (Lesson 3)	30

April						
SUN	MON	TUES	WED	THU	FRI	SAT
31	1 Teams go out (Lesson 4)	2 Teams go out (Lesson 4)	3 Teams go out (Lesson 4)	4 Teams go out (Lesson 4)	5 Teams go out (Lesson 4)	6
7	8 Make-up week	9 Make-up week	10 Make-up week	11 Make-up week	12 Make-up week	13
14	15	16	17	18	19	20
21	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.

EAST NASHVILLE MAGNET MIDDLE SCHOOL: 2000 GREENWOOD AVE **615-262-6670**

MARGARET ALLEN MIDDLE SCHOOL: 500 SPENCE LN **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

Mini lesson for Spring 2019

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.
  - Creatures that possess the advantageous variation will reproduce, represented by a green chip.
  - Creatures that possess the disadvantageous variation will get a red chip.
  - 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:
Pat Tellinghuisen, VSVS Program Coordinator, 1998-2018, Vanderbilt University
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

Evidence of a Chemical Reaction

Spring 2019

Goal: **To show students evidence of a chemical change.**
Fits TN standards:7PS1.2, 7PS1.3, 7PS1.4

VSVSer Lesson Outline

_______ I. Introduction

Question students about the difference between physical and chemical changes. Explain what constitutes evidence of chemical reactions.

_______ II. Safety Concerns

Discuss safety issues. Demonstrate how students will use the small dispensing bottles and the 24-well culture plate.

_______ III. Determining if a Chemical Change has Occurred

Tell students to follow the instructions on the instruction sheet. You will still need to guide them through the procedures, making sure they understand the instructions. Discuss results with students after they finish each row. Chemical equations for Rows A, B, C are given.

_______ **Row A: Chemical Reactions That Give a Precipitate (solid)**

Students should realize that if the solution turns cloudy, a solid (precipitate) is forming.

_______ **Row B: Chemical Reactions That Involve a Color Change**

Formation of complex ions cause color changes.

------------**Row C: Chemical Reactions That Produce a Gas**

Students look carefully at the bubbles (CO_2) produced in solutions.

--------- IV. Analyzing Results

Emphasize the chemistry of carbonates and bicarbonates. Students predict the reaction between marble and HCl.

-------- V. Identifying an Unknown

-------- VI. 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. 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 are some basic differences between a physical and chemical change?
2) What are signs of a chemical change?
3) What are the major safety concerns in this lesson for students?
4) What is important about the reaction between a carbonate/bicarbonate and an acid?
5) What is a precipitate?
6) Briefly describe the process students will use to “identify the unknown” at the end of the lesson
7) If a reaction causes the solution to go from colored to clear, does it count as a color change?
8) In all of the reactions in this lesson for which a gas is given off, what is the gas?

2. Use these fun facts during the lesson:

- Chemical changes constantly occur in living organisms. The human body is made up of proteins that help catalyze complex chemical reactions.
- The products of a chemical reaction have the same total mass as the reactants (law of conservation of mass).

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

- VSVSers do this while 1 person is giving the Introduction. Note that students are put into pairs and should have their pencils ready
- While one team member starts the introduction, another should write the following vocabulary words on the board:
  physical change, chemical change, chemical reaction, formula, solution, precipitate, compound, mixture

For Part III. Determining If a Chemical Change Has Occurred

34 safety goggles for students and VSVS members
16 24-well culture plates with lids
16 plastic plates
Instruction sheets, obs sheets
15 sets of dropper bottles of each:
1.0 M HCl hydrochloric acid
2.5 M Na_2CO_3 sodium carbonate
0.5 M $NaHCO_3$ sodium bicarbonate
0.1 M $Cu(NO_3)_2$ copper (II) nitrate
0.1 M $Fe(NO_3)_3$ iron (III) nitrate
0.1 M KSCN potassium thiocyanate

A. Demonstration Bag A – 2 oz bottle of 0.1 M $CaCl_2$, 2 oz bottle of 1 M Na_2CO_3, 2 10 oz clear cups 4 jars containing the products, with precipitate in bottom
B. Demonstration Bag B – 2 oz bottle of 0.05 M $Na_2S_2O_3$, 2 oz bottle of 0.01 M I_2, 2 10 oz clear cups
C. Demonstration Bag C - 2 oz bottle of 1 M HCl, jar of Na_2CO_3, 1 teaspoon, and 1 10 oz clear cup

For Part IV. Analyzing Results

15 small pieces of marble $CaCO_3$ (in a small bag)

For Part V. Optional: Identifying an Unknown

5 sets of 1oz dropper bottles of each of the following unknowns: Unknown A: $NaHCO_3$, Unknown B HCl, Unknown C: KSCN.

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I. Introduction

Learning Goals: Students can name the different indicators that a chemical reaction has occurred.

Ask students: *What is the difference between a physical change and a chemical change?*
Be sure to include the following information in the discussion:

- **A physical change** does not change the chemical properties of a substance.
  - No new substance is formed during a physical change.
  - Only the physical properties are changed.
  - Examples of physical changes include changes in the size, shape, or state of matter. For example, ice, liquid water, and steam. In each of these states, water has physically changed (from solid, liquid, gas) but not chemically.
- **A chemical change** does change the chemical properties of a substance.
  - One or more new substances are formed in a chemical change.
  - A chemical change cannot be easily reversed.
  - Examples include: burning paper, digestion of food, bananas browning

Ask students: How can you tell when a chemical change has occurred? *Some answers may include: a gas given off, color change, precipitation, explosion, burning, etc.*

Tell students what to look for to determine if a chemical change has occurred:

When solutions of two compounds are mixed, it is often possible to determine whether or not a chemical reaction has occurred through visual observation.

Evidence of a chemical change might be **a color change**, **a gas given off (it may smell)**, the **formation of a precipitate (a new solid), or an energy (temperature, light) change.**

Write these observations on the board and share the following explanation with students.

1. A **color change** occurs when two solutions are mixed and a new color is produced.
   - BUT, if the color of one solution becomes a paler shade, that change is caused by dilution from the other solution and does not qualify as a color change.
2. Bubbles or fizz indicate that a **gas is given off**.
   - BUT, make sure that students understand that the bubbles given off in a soda pop drink is NOT evidence of a chemical change This is just excess gas that is released when the top is opened. Carbonated beverages contain carbon dioxide gas dissolved under pressure, and removing the top lowers the pressure and allows carbon dioxide bubbles to escape.
3. A **precipitate** forms when two substances react to give a new solid compound that does not dissolve in water.
   - A precipitate will MOST LIKELY look like a cloudy solution, fine grains in a solution, a swirl, or a fluffy solid. The solution cannot be seen through.

Note: When two clear solutions are mixed and a white precipitate forms, this whitish color does not count as a color change. The change should be recorded only as the formation of a precipitate.

4. **An energy change (temperature or light)** can be either a physical or chemical change. A chemical

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energy change occurs in a glow stick when chemicals mix to produces light. A physical energy change occurs when you freeze water.

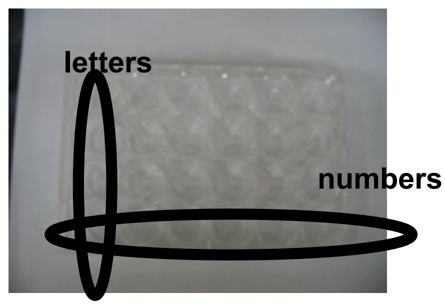
Important: Scientists do not rely on just visual observations to determine if a chemical or physical change has occurred. **The only real evidence is the formation of new substances with different chemical formulas from the reactants.**

II. Safety Concerns

- Tell students they must put on safety goggles before mixing any solutions.
- Students should not directly smell any chemicals.
- If anyone gets any of the chemicals on their skin or in their eyes, they should flush immediately with water. Although the solutions are dilute, they could still cause eye damage, especially the 1.0 M HCl.
- Emphasize to students how important it is for them to follow directions.

Organize students in **pairs** and distribute the following materials to each pair of students:

2 safety goggles
1 24-well culture plate
1 plastic plate
6 dropper bottles of solutions
2 Instruction Sheets
2 Chemical Reactions Observation Sheets



- VSVS volunteers should put on their safety goggles and keep them on until students are finished mixing chemicals.
- Have students look at the 24-well plate and the instructions at the top of the Chemical Reactions Lab Sheet.
- Show students how to find the letters A, B, C, D as well as the numbers 1 - 6 on the 24-well plate. (Letters are imprinted in the plastic along the right side; numbers are imprinted across the top and the bottom. These are tiny and may be difficult to see.)
- Show students how to **match the grid on the lab sheet to the 24-well plate**. Tell students to place the 24-well plate on the plastic plate.

Give the following instructions to the students:

1. The names and formulas of the compounds being used in this experiment are listed at the bottom of the observation sheet. Have students look at these names and formulas while you pronounce them for the class.
   The labels on the dropper bottles list both the name and formula. of the compounds.
   Show students how to be careful when matching the formulas (some of the formulas are very similar)**.**

2. Show students one of the bottles and demonstrate how to get drops out of the bottle. Dropper bottles are easy to use. Apply slow, gentle pressure. Do not remove the red cap from a bottle until it is to be used. Put the cap back on the bottle immediately after use.

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When using two solutions, put a squirt of the first solution in the correct well so that it is one-fourth full (we do not want students to spend time counting drops). Then add one squirt of the second solution. The well should now be half full.

3. Tell students they will perform the reactions for one row only then stop and discuss the results with the VSVS members. Tell the partners to take turns doing the experiments as they follow the grid on the lab sheet. Both students record their observations on the lab sheet. Students can record NR if No Reaction occurs. Otherwise, they will record color change, gas given off, or precipitate formed.

4. **Tell students to follow the instructions on the instruction sheet for mixing solutions.** (The instruction sheet lists the same directions as are given below.)

III. Determining If a Chemical Change Has Occurred

Learning Goals:
- **Students can name the different indicators that a chemical reaction has occurred.**
- **Students can identify the specific indicators of a reaction and explain how to look for them**

One team member should draw a grid of the well plate on the board with all of the rows labeled. Write on this when discussing the results with the students.

Note: VSVS volunteers need to monitor the students closely to be sure contamination does not occur. Ensure that students use the correct bottle.

Stop and discuss results with students after each row. This is preferable to waiting until students finish all of the experiment since some will finish very quickly and then be bored waiting for others to catch up.

The beginning of each reaction is given on the student observation sheet. Students and VSVSers should complete each equation on the board after the reactions in each row are completed.

A. Chemical Reactions that Give Precipitates - Row A

Demonstration: Show students what a precipitate looks like by doing the following demonstration. Take the demonstration bag marked ROW A. Remove the 2 oz bottles of solutions and the two 10 oz clear cups. Empty each 2 oz bottles into separate cups. Hold the two cups up so the students can see what happens, and then pour one solution into the other. A white solid (precipitate) forms. Point this out as an example of a chemical reaction in which a precipitate forms to the students.

Your Notes:

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Show the students the jars with the clear liquid and precipitate in the bottom. Tell them that these are the products from the same reaction just done, but the products were allowed to stand for several hours. Shake the jar to show the students that the solution will become cloudy again.

> **Note:** For each activity **DO NOT** record the results until the students have completed the experiments for the row since they may wait to copy the answers from the board.

Tell students to use the grid on their observation sheet to perform the experiments in Row A. Make sure that they correctly identify the formulas of the compounds being used in a reaction (listed on the observation sheet).

Review and Equations:

- Ask students what evidence indicated that a chemical reaction occurred.
    - *A precipitate formed in A1 and A2.*
- Put the results on the board. ***A1:*** *precipitate* ***A2:*** *precipitate*
- Students can look at the equations on the observation sheet:

  Demo: $CaCl_2 + Na_2CO_3 \rightarrow CaCO_3 + 2\ NaCl$

  A1: $2\ Fe(NO_3)_3 + 3\ Na_2CO_3 \rightarrow Fe_2(CO_3)_3 + 6\ NaNO_3$

  A2: $Cu(NO_3)_2 + Na_2CO_3 \rightarrow CuCO_3 + 2\ NaNO_3$

B. Chemical Reactions that Involve a Color Change - Row B

Demonstration: Show students what a color change looks like by doing the following demonstration.

- Take the demonstration bag marked ROW B. Remove the 2 oz bottles of solutions and the two 10oz clear plastic cups. Empty each 2 oz bottles into separate cups. Hold the two clear containers up, and tell students to notice that one is a clear colorless solution and the other is a clear, brown solution. Pour the colorless solution into the brown solution, and ask students to describe what happens. The brown solution turns colorless, but it is still clear (i.e no precipitation). Explain to students that a chemical reaction has taken place because the brown solution turned colorless upon addition of the clear solution.
- Tell students to use the grid on the lab sheet to perform the experiments in Row B.

> **Background for VSVS Members Only:** This is an oxidation-reduction reaction in which iodine is reduced to iodide ion, and thiosulfate ion, $S_2O_4^{2-}$, is oxidized to tetrathionate ion, $S_4O_6^{2-}$.

Review and Equations:

- Ask students what evidence indicated that a chemical reaction occurred.
    - A color change occurred.
- Put the results on the board. ***B1****: color change to deep red* ***B2:*** *color change to pale green.*

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Students can look at the equations on their observation sheet.

Demo: I_2 + 2 $Na_2S_2O_3$ → 2 NaI + $Na_2S_4O_6$

B1: $Fe(NO_3)_3$ + KSCN → $Fe(SCN)(NO_3)_2$ + KNO_3
intense red color

B2: $Cu(NO_3)_2$ + KSCN → $Cu(SCN)(NO_3)$ + KNO_3
pale green color

Background for VSVS Members Only: Color changes with metal ion solutions are caused by the formation of complex ions. In the present case, the SCN^- (thiocyanate) anion bonds strongly to the Fe^{3+} (iron) ion in solution to give an intense deep red color. The SCN^- anion also bonds to Cu(II) (copper) ion.

C. Chemical Reactions that Produce a Gas - Row C

Note: Tell students they will have to look very closely and quickly as soon as they add the second solution to the first solution. The bubbles of gas are small and come off as soon as the solutions are mixed.

Demonstration: Show students what a chemical change that produces a gas looks like by performing the demonstration first.

Take the demonstration bag marked ROW C. Hold the cup up and ask students to watch very carefully what happens.
Put 1 tsp of the solid (Na_2CO_3) into the cup and empty the 2oz bottle (HCl) into it.
Ask students to describe what happens.

A bubbling up (slight foaming) which quickly subsides indicates a gas is given off. Tell students to watch very carefully for bubbles of gas when they are doing **Row C** because they may be difficult to see.

- Tell students to use the grid on the lab sheet to perform all the experiments in Row C.

Review and Equations:

- Ask students what evidence indicated that a chemical reaction occurred.
  - *Bubbles/gas were given off.*
- Put the results on the board. ***C1****: bubbles/gas* ***C2:*** *bubbles/gas*
- Students can look at the equations on the observation sheet.

Demo: Na_2CO_3 + 2HCl → 2NaCl + CO_2 + H_2O

C1: $NaHCO_3$ + HCl → NaCl + CO_2 (g) + H_2O

C2: Na_2CO_3 + 2HCl → 2NaCl + CO_2 (g) + H_2O

IV. Analyzing Results

Learning Goals: Students can analyze compounds' reactions with one another and use that data to identify an unknown compound.

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Carbonates:

- Write CO_3 on the board and tell students that formulas that include "CO_3" as part of the formula are called **carbonates**.
- One form of carbonate, sodium carbonate is commonly referred to as "washing soda." It is part of many laundry detergents and dish washing detergents.
- Tell students to look at the ingredients of the copy of a **washing soda box on their Instruction sheet.** Sodium carbonate is listed as an ingredient.

Bicarbonates:

- Write HCO_3 on the board and tell students that formulas that include "HCO_3" as part of the formula are called **bicarbonates**.
- A common source of bicarbonate is **baking soda**, whose scientific name is sodium bicarbonate. Sodium bicarbonate is used for baking and as a deodorizer. Tell students to look at the ingredient label on baking soda and notice it says **sodium bicarbonate**.

Reactions of Carbonates and Bicarbonates:

- Ask students to look at each box in row C and circle the formulas that have "CO_3"or "HCO_3" as part of the formula. .
- Write HCl on the board.
  - Tell students that HCl is an acid called hydrochloric acid.
  - Tell students to put boxes around all the HCl's in Row C
- Ask students what happened in row C when an acid was added to a carbonate or bicarbonate.
  - *A gas was given off.*
  - Ask students if they have ever made a "volcano" at home or at school. Ask students if they remembered what they added to make the "lava". Most likely, they used vinegar and baking soda. Vinegar is an acid, and when added to baking soda (sodium bicarbonate), it bubbles as it releases a gas.
- Ask students what happens when you add an acid to carbonate or bicarbonate. *When an acid is added to a carbonate or bicarbonate a **chemical reaction occurs**. This is evidenced by the fact that a gas is given off.*
- Tell students that the gas given off in these reactions is carbon dioxide.

Identifying Carbonates Using Chemical Reactions:

- Tell students that chalk, limestone and marble are all calcium carbonate. If the formula for calcium carbonate is $CaCO_3$, what might happen if an acid (HCl) is added to marble? *It will bubble (give off a gas).*
- Write the first half of the equation, $CaCO_3$ (s) + HCl (aq) → ...on the board, and ask students to hypothesize what will happen, and what the products will be. ***The gas will be CO_2***

The full equation is:

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$$

- Have VSVS members hand out a piece of marble to each pair of students. Tell students that they are going to test their hypothesis to see if the marble will bubble when HCl is added.
- Have students add the marble to C5 and to squirt some HCl into the well. Ask students what happened. Was their hypothesis correct? *Yes, it should bubble when HCl is added.*

Your Notes:

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- Tell students that many statues are made of limestone and marble. Ask students what they think happens to statues when acid rain falls on them. *The carbonate in the statue reacts with acid liberating a gas and causing the statue to decompose*.

> **Background Information (in case students ask about acid rain)**: Acid rain is caused by the presence of varying amounts of sulfuric acid and nitric acid in rain drops. Fossil fuels, particularly coal and oil, contain sulfur as an impurity. When fossil fuels are burned, the sulfur combines with oxygen to form sulfur oxides that are gases released into the air. When it rains, the water reacts with these gases to form sulfuric acid. When vehicles burn gasoline or diesel fuel, nitrogen oxides are emitted into the air, and these react with water to produce nitric acid. The amount of sulfuric acid and nitric acid in acid rain depends on the location. The acid rain in Nashville is primarily caused by nitric acid from the high density of vehicles, while the acidity of rain in industrialized areas will be caused by the presence of both sulfuric and nitric acids. As a result of the Clean Air Act, industrial and power plants are emitting much lower amounts of sulfur oxides; however, the emission of nitric oxides from vehicle exhausts is still a problem.

V. Optional: Identifying an Unknown

Tell students they will be given a colorless solution that contains one of the following compounds dissolved in water

Unknown A: $NaHCO_3$
Unknown B: HCl
Unknown C: KSCN

These are the same colorless solutions that they have been doing the experiments wit.
Tell them that they will follow a plan, using the dropper bottles from the chemical reaction kit, to determine the identity of the unknown.
Students can work in pairs, groups, or as a class. There is a total of 15 dropper bottles.
Distribute the unknown dropper bottles throughout the class, so that pairs or groups of students have access to one unknown.
Tell students to:

1. Follow the plan in Row D and add a squirt of their unknown to the 6 wells in Row D of the well plate.
2. Add a few drops from their known dropper bottles, one well at a time.
3. Write down the observation immediately after each addition.
4. Look at the results in Rows A, B and C, to determine what the possible reactions are.

Ask students: What do you think your unknown is? _____________
If the students have trouble, tell them to compare what happened in their reactions to what happened in the earlier reactions. For example, if their unknown causes precipitates to form with iron nitrate and copper (II) nitrate, then it has to be sodium bicarbonate.
What is your proof for what you've listed in (a)?
The proof should be stated something like the answer response in the plans given above but specific for the unknown. For example, if the unknown was HCl, the proof statement could be: the unknown made the $NaHCO_3$ and Na_2CO_3 fizz.
Note: The students cannot distinguish between **$NaHCO_3$ and Na_2CO_3** with the chemicals they have been given.

Your Notes:

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Write balanced chemical equations for the reactions you used to determine the identity of the unknown. (**Refer to equations in lesson (Section VIII)**)

Optional: Answer these questions after finishing the chemical reactions observation sheet.

1. Write complete, balanced equations for the following:
    a. One reaction in Row A that gave a precipitate.
    Refer to equations in lesson (Section VIII)
    b. One reaction in Row B that gave a color change.
    Refer to equations in lesson (Section VIII)
    c. One reaction in Row C that gave a gas.
    Refer to equations in lesson (Section VIII)

VI. Review Questions

Ask students**:**

- What is a physical change?
- What is a chemical change?
- What are the chemical changes we saw today?
- How do we know when a chemical change has occurred? (answer on p. 3)

VII. Clean-up

- Have students put the dropper bottles back in the Ziploc bag. **Make sure that the bottles are all upright. Leaks make for nasty clean-up tasks.**
- Collect the Ziploc bags and the goggles.
- Place the lids on the 24-well plates and carefully put them in the Rubbermaid container. Place the lid on the Rubbermaid container and put it in the bottom of the box. (If you can rinse them out at the school, do so, PLEASE)
- Place the ziploc bags and other materials in the box.
- Collect all instruction sheets in sheet protectors and put them in the box.

Lesson written by Dr. Melvin Joesten, Chemistry Department, Vanderbilt University
Pat Tellinghuisen, Program Coordinator of VSVS 1998-2018, Vanderbilt University

Your Notes:

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Class Activity Sheet – Extension Activity

NAME ____

1. You will be given an unknown colorless solution that contains one of the following compounds dissolved in water: KSCN, HCl, $NaHCO_3$. Follow Row D to determine the identity of your unknown.
   a. What do you think your unknown is? _____________ If there is more than one possibility, list both.

   b. What is your proof for what you've listed in (a)?

   c. Write balanced chemical equations for the reactions you used to determine the identity of the unknown.

1. Write complete, balanced equations for the following (choose a correct equation from the list below):
   a. One reaction in Row A that gave a precipitate.

   b. One reaction in Row B that gave a color change.

   c. One reaction in Row C that gave a gas.

Chemical Equations for Chemical Reactions in this Lesson

Abbreviations: s = solid, aq = aqueous, g = gas, l = liquid

$CaCl_2$ (aq) + Na_2CO_3 (aq) → $CaCO_3$ (s) + 2 NaCl (aq)

2 $Fe(NO_3)_3$ (aq) + 3 Na_2CO_3 (aq) → $Fe_2(CO_3)_3$ (s) + 6 $NaNO_3$ (aq)

$Cu(NO_3)_2$ (aq) + Na_2CO_3 (aq) → $CuCO_3$ (s) + 2 $NaNO_3$ (aq)

I_2(aq) + 2 Na_2S2O_3(aq) → 2 NaI(aq) + $Na_2S_4O_6$ (aq)

$Fe(NO_3)_3$ (aq) + KSCN (aq) → $Fe(SCN)(NO_3)_2$ (aq) + KNO_3 (aq)

$Cu(NO_3)_2$ (aq) + KSCN (aq) → $Cu(SCN)(NO_3)$ (aq) + KNO_3 (aq)

Na_2CO_3 (s) + 2HCl (aq) → 2NaCl (aq) + CO_2 (g) + H_2O (l)

$NaHCO_3$ (aq) + HCl (aq) → NaCl (aq) + CO_2 (g) + H_2O (l)

Na_2CO_3 (aq) + 2HCl (aq) → 2NaCl (aq) + CO_2 (g) + H_2O (l)

$CaCO_3$ (s) + 2HCl (aq) → $CaCl_2$ (aq) + CO_2 (g) + H_2O (l)

Your Notes:

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Class Activity Sheet
ANSWER SHEET

Answer these questions after finishing the chemical reactions observation sheet.

2. Write complete, balanced equations for the following:
   a. One reaction in Row A that gave a precipitate.
   Refer to equations on worksheet
   One reaction in Row B that gave a color change.
   Refer to equations on worksheet
   One reaction in Row C that gave a gas.
   Refer to equations in lesson (Section VIII)

2. 2. You will be given an unknown colorless solution that contains one of the following compounds dissolved in water: KSCN, HCl, $NaHCO_3$. Follow Row D to determine the identity of your unknown.

   What do you think your unknown is? ______________

5. What is your proof for what you've listed in (a)?
The proof should be stated something like the answer response in the plans given above, but specific for the unknown. For example, if the unknown was $CaCl_2$, the proof statement could be: A precipate formed when $NaHCO_3$**solution was added. The $CaCl_2$ solution is the only one of the possible unknowns that will give a precipitate with** $NaHCO_3$**.**

6. Write balanced chemical equations for the reactions you used to determine the identity of the unknown.
   Refer to equations below

Chemical Reactions Observation Sheet

Name________________________________

Vocabulary Words: physical change, chemical change, chemical reaction, formula, solution, precipitate, compound, mixture

In each box, use the following choices to record your observations: color change, precipitate formed, gas given off, NR (no reaction)

Add other observations if you wish. Ex: lots of bubbles, fizz, small or large bubbles, cloudy precipitate.

A1 $Fe(NO_3)_3$ + Na_2CO_3	**A2** $Cu(NO_3)_2$ + Na_2CO_3	**A3**	**A4**	**A5**	**A6** **Demonstration** $CaCl_2 + Na_2CO_3$	$CaCl_2 + Na_2CO_3 \rightarrow CaCO_3 + 2NaCl$ $2 Fe(NO_3)_3 + 3 Na_2CO_3 \rightarrow Fe_2(CO_3)_3 + 6 NaNO_3$ $Cu(NO_3)_2 + Na_2CO_3 \rightarrow CuCO_3 + 2 NaNO_3$
B1 $Fe(NO_3)_3$ +KSCN	**B2** $Cu(NO_3)_2$ +KSCN	**B3**	**B4**	**B5**	**B6** **Demonstration** $I_2 + 2Na_2S2O_3$	$I_2 + 2 Na_2S_2O_3 \rightarrow 2 NaI + Na_2S_4O_6$ $Fe(NO_3)_3 + KSCN \rightarrow Fe(SCN)(NO_3)_2 + KNO_3$ $Cu(NO_3)_2 + KSCN (aq) \rightarrow Cu(SCN)(NO_3) + KNO_3$
C1 baking soda $NaHCO_3$+ HCl	**C2** washing soda Na_2CO_3 + HCl	C3	C4	C5 marble solid $CaCO_3$ + HCl	**C6** **Demonstration** $Na_2CO_3 + 2HCl$	$Na_2CO_3 + 2HCl \rightarrow 2NaCl + CO_2 + H_2O$ $NaHCO_3 + HCl \rightarrow NaCl + CO_2 + H_2O$ $Na_2CO_3 + 2HCl \rightarrow 2NaCl + CO_2 + H_2O$ $CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$
D1 $NaHCO_3$ + unknown	**D2** KSCN + unknown	**D3** $Fe(NO_3)_3$ + unknown	**D4** $Cu(NO_3)_2$ + unknown	**D5** HCl + unknown	**D6**	

HCl - hydrochloric acid Na_2CO_3 – sodium carbonate $NaHCO_3$ – sodium bicarbonate $Cu(NO_3)_2$ – copper (II) nitrate $Fe(NO_3)_3$ – iron (III) nitrate

KSCN – potassium thiocyanate $CaCl_2$ – calcium chloride

Chemical Reactions Lab Sheet
Answer Key

A1 $Fe(NO_3)_3 + Na_2CO_3$ precipitate	**A2** $Cu(NO_3)_2 + Na_2CO_3$ precipitate	**A3**	**A4**	**A5**	**A6** **Demonstration** $CaCl_2 + Na_2CO_3$ white precipitate
B1 $Fe(NO_3)_3$+KSCN color change- deep red	**B2** $Cu(NO_3)_2$ +KSCN color change - pale green color	**B3**	**B4**	**B5**	**B6** **Demonstration** I_2 + 2 Na_2S2O_3 color change – brown to colorless
C1 baking soda $NaHCO_3$+ HCl gas given off	**C2** washing soda Na_2CO_3 + HCl gas given off	**C3**	**C4**	**C5** marble solid $CaCO_3$ + HCl gas given off	**C6** **Demonstration** Na_2CO_3 + 2HCl gas given off
Answers for unknowns on separate page					**D6**

HCl - hydrochloric acid Na_2CO_3 – sodium carbonate $NaHCO_3$ – sodium bicarbonate $Cu(NO_3)_2$ – copper (II) nitrate $Fe(NO_3)_3$ – iron (III) nitrate
KSCN – potassium thiocyanate $CaCl_2$ – calcium chloride

Answer Sheet for Unknown Solutions

baking soda $NaHCO_3$+ **unknown A ($NaHCO_3$)** NR	potassium thiocyanate KSCN+ **unknown A ($NaHCO_3$)** NR	iron nitrate $Fe(NO_3)_3$+ **unknown A ($NaHCO_3$)** PPT	copper nitrate $Cu(NO_3)_2$+ **unknown A ($NaHCO_3$)** PPT	hydrochloric acid HCl + **unknown A A ($NaHCO_3$)** Gas given off	
baking soda $NaHCO_3$ + **unknown B (HCl)** Gas given off	potassium thiocyanate KSCN + **unknown B (HCl)** NR	iron nitrate $Fe(NO_3)_3$ + **unknown B (HCl)** Color change	copper nitrate $Cu(NO_3)_2$+ **unknown B (HCl)** Color change	hydrochloric acid HCl + **unknown B (HCl)** NR	
baking soda $NaHCO_3$+ **unknown C (KSCN)** NR	potassium thiocyanate KSCN + **unknown C (KSCN)** NR	iron nitrate $Fe(NO_3)_3$ + **unknown C (KSCN)** Color change	copper nitrate $Cu(NO_3)_2$+ **unknown C (KSCN)** Color change	hydrochloric acid HCl + **unknown C (KSCN)** NR	

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

Igneous Rocks

Spring 2019

Goal: To introduce students to the types of igneous rocks, how they form, and what minerals combine to form them.

Fits Tennessee 8.ESS.2.3

VSVSer Lesson Plan

_______ **I. Introduction – What are Igneous Rocks?**

- **A.** Definitions – How are igneous rocks formed?
- **B.** Lava versus Magma

_______ **II. Examining Igneous Rocks**

- **A.** Intrusive vs. Extrusive Igneous Rocks
- **B.** Basaltic vs. Granitic Rocks
- **C.** Minerals of Igneous Rocks
- **D.** Examining Pegmatite

_______ **III. Where do these Igneous Rocks come from?**

_______ **IV. Examining Volcanic Rock**

- **A.** Stratovolcanoes vs. Shield Volcanoes
- **B.** Special Types of Volcanic Rock

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

Divide class into 16 pairs. Hand out an Igneous Rock observation sheet to each student.

Unpacking the Kit:

VSVSers do this while 1 person is giving the Introduction. Note that students are put into pairs and should have their pencils ready

For Part II: Examining Igneous Rocks

16 Plastic Cases containing one set of Igneous Rocks, 1 set of minerals and 1 piece of pegmatite.
32 Magnify Glasses

For Part IIB, IIC and IID and Part III: 16 laminated mats for igneous rocks and 16 Venn diagrams.

For Part IV. Examining Volcanic Rocks

16 Volcano diagrams in sheet protectors
Deep plastic box with lid containing:1 Margarine container, 2 Lids (1 with multiple small holes and 1 with no holes), 16oz of water, Small plastic plate, Small dropper bottle of detergent, Small container of dry ice, A pair of tongs, 2 goggles for VSVSers

For Part B. Special Types of Volcanic Rock

1 clear 16oz cup, 8 Plastic Cases containing two sets of Volcanic Rocks (2 pairs of students will share the case), 16 magnifying glasses from Part III

I. Introduction – What are Igneous Rocks?

Why is the science in this lesson important?

Igneous rocks are a rich source of minerals and ores Minerals are vital to our everyday lives: for example, minerals are an important component of iPhones, computer chips, and magnets. New processes are currently being developed to allow us to more efficiently extract the minerals that we are currently using, as well as extract completely new materials. Careers involving innovation in the mining and metallurgy industries are extremely important in ensuring that humans use our limited supply of resources sustainably.

Learning Goals: Students understand that igneous rocks are formed above and below the earth's surface by cooling melted rock.

Write the following vocabulary on the board: **magma, lava, intrusive igneous rock, extrusive igneous rock, granitic, basaltic, intermediate, mineral, shield volcano, stratovolcano, volcanic rock**

A. Definitions – How are igneous rocks formed?

There are 3 types of rocks - sedimentary, metamorphic and igneous. This lesson focuses on igneous rocks.

Ask students if they know how igneous rocks are formed and what they are formed from.

- Igneous rocks form when the melted rock material from the Earth cools.
- Cooling and hardening of melted rock material can occur on or underneath Earth's surface.

B. Lava Versus Magma

- Tell them that melted rock material is called **magma** when it is ***underneath*** the Earth's surface. Igneous rocks made from **magma** form ***underneath*** the Earth's surface and are called **intrusive igneous rocks**
- When the melted material is ***on or above*** the Earth's surface, it is called **lava**. Igneous rocks formed from **lava** form ***on or above*** the Earth's surface and are called **extrusive igneous rocks.**

Tell the students that they will:

- Look at different samples of igneous rocks
- Look for visible differences between **intrusive** and **extrusive** igneous rocks
- Learn about some of the different **minerals** that make up **igneous rocks**
- Examine some different types of volcanic rocks and relate them to the type of volcano they come from.

II. Examining Igneous Rocks

Learning Goals: Students identify the differences between different types of igneous rocks and how minerals impact the qualities of each igneous rock type.

Materials:

17 Plastic Cases with one set of Igneous Rocks, 1 set of minerals and 1 piece of pegmatite.
32 Magnifying Glasses

A. Intrusive Versus Extrusive Igneous Rocks

Hand out igneous rock, minerals and pegmatite box to each pair and a magnifying glass to each student. Tell students to remove the rocks (A-F) from the box. Leave the minerals and pegmatite in the box.

Your Notes:

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- Scientists can classify rocks as *fine-grained* or *coarse-grained*. Coarse-grained rocks have large crystals of different minerals, and fine-grained rocks have very small crystals that are difficult to see.
- **Extrusive igneous rocks** cool and harden much more quickly since they form at the Earth's surface where the temperature is cooler. Since they cool quickly there is not as much time for large, visible crystals to form. **Extrusive rocks are fine grained**
- **Intrusive igneous rocks** form deep within the Earth where they cool much more slowly because the temperature is higher. Crystals have more time to grow larger. **Intrusive rocks are coarse grained.**

Tell students to sort the rocks into 2 sets - fine and course grained.

Ask students what rocks are fine grained and which are course grained.

A, B, C have no crystals and are fine-grained. D, E, F have large crystals and are course-grained.

B. Basaltic Versus Granitic Rocks

- The color of a rock depends on the elements in the minerals in the rock.
- **Granitic (also called Felsic)** rocks are light-colored because they contain minerals that have more silicon, sodium, aluminum and potassium (don't emphasize elements, focus on the color).
  - Granite is the most common granitic rock.
- **Basaltic (also called Mafic)** rocks are dark-colored and contain minerals that have more calcium, iron and magnesium.
  - Basalt *(buh-salt)* is the most common Basaltic rock.

Tell students to sort the rocks into 2 sets - light-colored and dark-colored.

They might have trouble classifying rocks B and E. Tell the students that these rocks are called **<u>intermediate</u>** because they are made from a mix of Granitic and Basaltic lava.

Ask students which rocks they think are Granitic *(A and D)*, Basaltic *(C and F)*.

<u>Pass out the laminated mats for igneous rocks AND the Venn diagram (1 per pair).</u>

	Basaltic/Mafic Igneous Rocks	Intermediate Igneous Rocks	Granitic/Felsic Igneous Rocks
Extrusive Igneous Rocks Formed **above** Earth's surface from **lava**	Basalt C *[BUH-SALT]*	Andesite B *[AND-UH-SIGHT]*	Rhyolite A *[RYE-OH-LIGHT]*
Intrusive Igneous Rocks Formed **below** Earth's surface from **magma**	Gabbro F *[GAB-ROW]*	Diorite E *[DIE-OH-RIGHT]*	Granite D *[GRAN-IT]*

Refer to the images as you talk about key terms below

Tell students to place the rocks on the chart, matching the letters to the corresponding spaces.

Walk around and help them to do this as needed.

Explain that:

- The top row contains **<u>Extrusive</u> Igneous Rocks** that formed from **lava** on the **Earth's surface.** These rocks are fine-grained.
- The bottom row of rocks contains **<u>Intrusive</u> Igneous Rocks** that formed from **magma below the Earth's surface**. These rocks are coarser grained ("speckled"). Students may or may not know that the "specks" are crystals of minerals.

Your Notes:

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- The color gradually gets lighter from left to right.
- The rocks in the blue column are lighter in color and are Granitic
- The rocks in the red column are darker and are Basaltic.

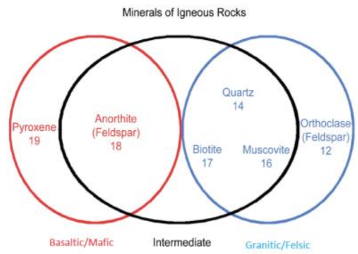
Tell students that the reason for the difference in colors will be more obvious after they have examined the minerals that make up the rocks.

C. Minerals of Igneous Rocks

Learning Goal: Students remember that minerals are the building blocks of rocks

Tell students to place the Venn diagram below the igneous rock mat.

Have the students place the minerals on the diagram, matching the numbers to the corresponding spaces. Remind students that **minerals** are the building blocks of rocks. The igneous rocks are different combinations of these minerals.



The colored circles/ovals in the Venn Diagram correspond to the three columns in the table:

- Any mineral in the blue circle can be found in a granitic/felsic rock.
- Any mineral in the black circle can be found in an intermediate rock.
- Any mineral in the red circle can be found in a basaltic/mafic rock.
- Minerals in overlapping ovals can be found in both corresponding rock types

***Ask students*:**

- What difference do they see in the colors of the minerals?
  The color gradually gets lighter from left to right.
- What is the relationship between the color in the minerals and rocks?
  The color of the rock depends on the minerals that make up the rock. The minerals that make up the basaltic rocks tend to be darker than those that make up the granitic rocks. Intermediate rocks are made from some granitic minerals and some basaltic minerals.

D. Examining Pegmatite

Tell students to look at the large-grained igneous rocks (D, E and F) and the pegmatite (H) with the magnifying glasses to observe the minerals in them. Note: The name **Pegmatite** refers to an igneous rock with especially large mineral crystals. It does not have a specific mineral composition.

Walk through the minerals of the pegmatite with the students:

Using the minerals placed on the Venn diagram as a reference, ask students if they can see: *Orthoclase feldspar, quartz, muscovite, and biotite.*

Note: If the samples have a salmon/pink colored mineral, point out to students that it is a type of orthoclase feldspar (12) that has impurities that makes it pink instead of the white mineral they have in front of them.

Tell students that other minerals are present but that we have listed only the largest/easiest to see.

Your Notes:

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Based on the minerals listed, ask the students:

Is the pegmatite intrusive or extrusive? *Intrusive because it has large crystals*

Is the pegmatite granitic, intermediate, or basaltic? *Granitic because it's made of the minerals that are found in granitic rocks. It may also be lighter in color.*

III. Where do these Igneous Rocks come from?

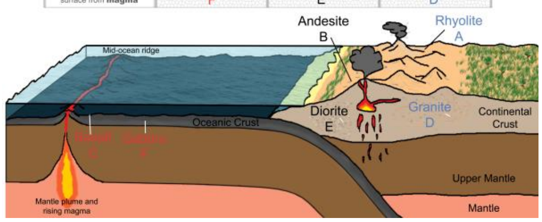
Learning Goals: Students identify the source of different igneous rock types.

Have the students place the rocks on their labels on the landscape diagram below the chart.

Tell students to notice where these rocks are forming.

- Darker basaltic rocks form from cooling of lava or magma from the ocean splitting apart at rifts, also called mid-ocean ridges.
- Lighter granitic rocks form from violent eruptions of volcanoes on land.

	Basaltic/Mafic Igneous Rocks	Intermediate Igneous Rocks	Granitic/Felsic Igneous Rocks
Extrusive Igneous Rocks Formed **above** Earth's surface from **lava**	Basalt C	Andesite B	Rhyolite A
Intrusive Igneous Rocks Formed **below** Earth's surface from **magma**	Gabbro F	Diorite E	Granite D



Ask the students to put their rocks and minerals back in their boxes so that VSVS volunteers can collect the boxes and the mats while setting up for the next part of the lesson.
VSVS volunteers MUST look at every box before they remove them from the table, to make sure all materials have been put back.

IV. Examining Volcanic Rocks

Learning Goals: Students observe demonstrations to understand how shield and stratovolcanoes can produce igneous rock.

Pass out one volcano diagram to each pair.

Ask the students if they know the difference between a **shield volcano** and a **stratovolcano** (also known as **Cinder Cone volcanoes).**
Shield volcanoes *are broad volcanoes that have slow moving lava flows.*
Stratovolcanoes *are tall, steep volcanoes that erupt explosively.*

Tell students to look at the Volcano diagram handout and explain the difference between the 2 volcanoes

SHIELD VOLCANOES:

- Are named because they look like upside down shields.
- Are spread out over a wide area and are almost continuously erupting.

Your Notes:

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- Form as lava flows in all directions, cools, and builds up in layers over time.
- Can be found in Hawaii. Lava from Kilauea Volcano was in the news in 2015, as it flowed towards a shopping center.
- Tend to have **basaltic** lava, which flows easily.

STRATOVOLCANOES (Cinder Cone volcanoes):
- Are usually very tall and very steep.
- Erupt explosively all at once, sending out clouds of hot ash and gases as well as flows of lava.
- Mt. St. Helens and Vesuvius – the volcano that destroyed Pompeii – are both stratovolcanoes.
- Stratovolcanoes tend to have **granitic** lava, which flows slowly.

Additional Information for VSVS members:
Stratovolcanoes are more explosive in nature and deadlier. They are often found on shores because of plates moving underneath the Earth's surface. These volcanoes are very dangerous because of ash clouds and pyroclastic flows that form when they erupt. Ash clouds can form a glassy layer inside the lungs, which end up suffocating the victim. Pyroclastic flows are extremely fast and large clouds of hot gas whose temperature can reach up to 300°F and can travel at speeds of 200 miles per hour.

A. Demonstration - Stratovolcanoes vs. Shield Volcanoes

Materials:

Deep plastic box with lid containing:

1	Margarine container
2	Lids – 1 with multiple small holes and 1 with no holes
16oz	water
1	Small plastic plate
1	Small dropper bottle of detergent
1	Small container of dry ice
1	Pair of tongs

SAFETY GUIDELINES:
1. **VSVS VOLUNTEERS MUST WEAR SAFETY GOGGLES WHILE DOING THIS DEMONSTRATION.**
2. **KEEP THE MARGARINE CONTAINER IN THE BOX FOR THE STRATOVOLCANO DEMONSTRATION.**
3. **USE THE TONGS TO HANDLE DRY ICE**

Tell students that we will be demonstrating shield volcano and stratovolcano eruptions.

For the shield volcano:
1. Take the margarine container out of the box and place it on the small plastic plate so that the students can see the demonstration better.
2. Fill the margarine container 2/3 of the way full with water.
3. Add one squirt of laundry detergent to the water.
4. Using the tongs, drop 2 pieces of dry ice into the container.
5. Quickly place the lid *with multiple small holes* on top of the container, making sure to press it on fully.

Your Notes:

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The mixture should start to slowly ooze out of the holes in the lid. Explain that this is similar to how lava in a shield volcano eruption slowly leaves the volcano and slowly flows down around all sides.

For the stratovolcano:

1. Put the margarine container back in the deep plastic box.
2. Make sure the margarine container is 2/3 full of water.
3. Using the tongs, drop 2 pieces of dry ice into the container.
4. Quickly place the lid *without holes* on top of the container, making sure to press it on fully.
5. Step back and watch the lid first bulge and then fly off.

Point out that lid bulges as gas builds up inside the margarine container– this didn't happen with the shield volcano.
This is similar to how gas builds up in a stratovolcano just before it explosively erupts, sending material (and lava) outwards in all directions, just as the lid violently flew off.

Repeat the demonstrations, making sure to point out the slow oozing of the shield volcano demo and the **lid bulging** before the eruption in the stratovolcano demo.

B. Special Types of Volcanic Rock

Materials:

1 clear 16oz cup
8 Plastic Cases with two sets of Volcanic Rocks - (Box #4 – 2 pairs of students will share the case)
16 magnifying glasses from Part III

Pass out the cases of volcanic rocks labeled (M-T). Each group of four should get one case that contains two sets of rocks.

Tell students that these are special kinds of igneous rocks called **volcanic rocks** because they come from volcanoes. **All of the rocks in the cases come from stratovolcanoes.**

Have students work with their partner to make observations about each rock.
As they make observations, they should fill in the chart on the back of their observation sheets.
If time is short, discuss the differences between the rocks as a class and take notes on the board.

While the students are working, walk around and engage them in conversation about what they are observing and make sure that they are recording their observations on their observation sheet.
After a few minutes, have the students stop working, and ask them about their observations.

- Pronounce the name of each rock
- Ask them what they observed or what they think makes the rock unique
- Mention some (**not all**) of the fun facts provided for each rock below.

Your Notes:

Volcanic Rock Fun Facts:

M. Vesicular Basalt (***veh-sick-you-ler buh-salt***)

- This rock is made of the same minerals as the basalt we looked at earlier.
- The word *vesicular* means it has small cavities or air pockets because the gas didn't escape before the rock cooled.

N. Scoria (***skur-ree-uh***)

- It is made from lava that had a lot of gases trapped inside.
- These gases form large bubbles in the lava which remain as **holes or cavities** in the solid rock.

O. Pumice (***pum-iss***)

- When lava is extremely rich in gases, it can begin frothing or foaming.
- When this **foam is violently ejected** from the volcano and **solidifies**, pumice is formed.
- Pumice will **float on water**.
- Pumice is commonly used as scouring stones or in exfoliating creams.

Show students that pumice will float – use the 16 oz cup, add water, and add a piece of pumice.

P. Obsidian (***ub-sid-dee-in***)

- Obsidian is also known as **volcanic glass**, and has a **smooth, glassy appearance**.
- It is formed when lava from a volcano **flows into water** (a lake or ocean), which causes it to cool so quickly that **no mineral crystals can form**.
- The red streaks tell us **how the lava was flowing** when it cooled.
- In the past, obsidian was used to make arrowheads and other tools.

R&T. Ash Tuff (***ash tough***) **& Vitric Tuff** (***vit-trick tough***)

- Volcanic tuff is rock formed when **debris** from an explosive volcano piles up and is later **compressed into a solid rock**.
- Sample **R** is called ash tuff because it is mainly composed of **volcanic ash** pressed together to form a solid rock.
- The word *vitric* means glassy, and vitric tuff is made up of bits of volcanic glass (obsidian).

CLEAN UP:

1. **Collect all volcanic rocks and put into cases in their labeled positions.**
2. **Collect the volcano diagrams and the magnifying glasses.**
3. **Empty the liquid from the margarine container.**

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Reference: Chernicoff, S., & Whitney, D. (2007). *Geology: An Introduction to Physical Geology*. Upper Saddle River, New Jersey: Pear

Your Notes:

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Igneous Rock Observation Sheet

Name ____

I. Introduction – What are Igneous Rocks? – Circle your answer

1. (Sedimentary, metamorphic, igneous) rocks form when melted rock material cools.

2. Igneous rocks formed from lava form *on or above* the Earth's surface are called (intrusive, extrusive) igneous rocks.

3. Igneous rocks formed from magma *underneath* the Earth's surface are called (intrusive, extrusive) igneous rocks.

II. Examining Igneous Rocks

4. Which kind of rock – Granitic or Basaltic – tends to be light in color?

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5. In your chart, what differences do you notice between the extrusive igneous rocks in the top row and the intrusive igneous rocks in the bottom row?

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6. Circle your answer: The color of an igneous rock is determined by (where it forms, what minerals it is made of, the temperature of the lava around it).

7. What minerals do you observe in the pegmatite sample?

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8. Do you think pegmatite is intrusive or extrusive? Why?

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IV. Examining Volcanic Rock

Volcanic Rock:	What do you observe? What makes this rock unique?
Vesicular Basalt (M)	
Scoria (N)	
Pumice (O)	
Obsidian (P)	
Ash Tuff (R)	
Vitric Tuff (T)	

Igneous Rock Observation Sheet Answers

I. Introduction – What are Igneous Rocks? – Circle your answer

1. (Sedimentary, metamorphic, ***igneous***) rocks form when melted rock material cools.

2. Igneous rocks formed from lava form *on or above* the Earth's surface are called (intrusive, ***extrusive***) igneous rocks.

3. Igneous rocks formed from magma *underneath* the Earth's surface are called (***intrusive***, extrusive) igneous rocks.

II. Examining Igneous Rocks

4. Which kind of rock – granitic or basaltic – tends to be light in color? ***Granitic***

5. In your chart, what differences do you notice between the extrusive igneous rocks in the top row and the intrusive igneous rocks in the bottom row? ***The extrusive igneous rocks in the top row are fine-grained, whereas the intrusive igneous rocks in the bottom row are speckled/have visible crystals.***

6. Circle your answer: The color of an igneous rock is determined by (where it forms, ***what minerals it is made of***, the temperature of the lava around it).

7. What minerals do you observe in the pegmatite sample? ***Orthoclase feldspar, quartz, muscovite, and biotite***

8. Do you think pegmatite is intrusive or extrusive? Why? ***Intrusive because it has large crystals***

IV. Examining Volcanic Rock

For the chart, possible answers include the appearances of the rocks, how shiny they are, how heavy they are (pumice should be very light, for example), or anything else observable about the rock

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http://studentorg.vanderbilt.edu/vsvs

Stratigraphy

Spring 2019

Goal: To introduce students to the geological time scale, fossils, sedimentary rock columns, index fossils, and column correlation methods.
Fits TN Standards 8.ESS.2.3

VSVSer **Lesson Outline:**

I. Sedimentary Rock Layers/Columns

_______ A. Sedimentary Rocks
_______ B. Creating a Model of Sedimentary Layers
_______ C. Explaining the Column
_______ D. Index Fossils and Radioactive Dating
_______ E. Finding the Ages of the Layers in Our Column
_______ **II. Stratigraphy (Correlating Columns)**
_______ **IIB. Correlating Stratigraphic Columns**
_______ **III. Timeline of the Earth**

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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.

Stratigraphy Lesson Quiz

1. How do sedimentary rocks form?
2. What is the age of a fossil relative to the rock in which it is found?
3. Which layer in a stratigraphic column is the oldest?
4. Explain how you can compare two different stratigraphic columns from different parts of the world.
5. Give an example of an index fossil and explain why it is useful..

2. During the Lesson:

Here are some fun facts for the lesson

1. Nashville sits in a valley surrounded by limestone layers. Fossils can be seen embedded in the limestone.
2. Evidence for the asteroid that killed the dinosaurs is seen in various stratigraphic columns. There is a worldwide layer of iridium dating back to the time when the dinosaurs were wiped out. Iridium is more common in meteorites than it is on Earth.
4. Trilobites are commonly used as index fossils to determine the age of certain landmarks. They are great for determining the movement of plate tectonics. Scientists today are still unsure of why the trilobites went extinct.

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

IB. Creating a Model of Sedimentary Layer

For demonstration:

1 box containing materials for demonstrating the layering:
1 plate, 1 column container, 1 bottle of water
Jars 1-5 of sand, with different colors of sand representing different types of sedimentary rock and different stones representing fossils:

For students:

10 plates, 10 column containers (jars containing water), 10 bags containing jars of sand (to represent different types of rocks and fossils):

- Jar 1: White sand containing black rocks
- Jar 2: Orange sand containing white rocks
- Jar 3: Black sand
- Jar 4: White sand containing white rocks
- Jar 5: Tan sand containing white rocks and tan/red rocks

36 observation sheets
20 Handouts with Column Diagram,

ID. Index Fossils and Radioactive Dating

10 models of rock layers/fossils encased in boxes

IIA. Stratigraphy (Correlating Columns)

20 sets of colored stratigraphic columns (National Park Sequences)

IIB. Correlating Stratigraphic Columns

20 sets of 3 stratigraphic sequences

For Part III. Timeline of the Earth

1 cylinder containing the string timeline

I. Sedimentary Rock Layers/Columns

Learning Goals:
- **Students understand how sedimentary rocks are formed.**
- **Students experiment with forming sedimentary layers and understand that fossils are deposited at the same time the as the sediment.**
- **Students understand that sediments are deposited in horizontal layers**
- **Students understand that older layers are at the bottom in a sedimentary layer, while younger layers are at the top**

Why is the science in this lesson important?

An understanding of stratigraphy is useful for understanding when and how life originated on Earth, as well as for studying evolution and historical changes in Earth's ecosystems. Potential careers that benefit from an understanding of stratigraphy include paleontologists, archaeologists, and soil scientists.

A. Reviewing Sedimentary Rocks

- Q. Ask students what they know about sedimentary rocks. If these answers aren't given, go over them briefly:
  - Most sedimentary rocks are formed from sediments deposited in oceans, lakes or rivers.
  - Sediments form layers that pile on top of each other, which compress over time to create rock.

Your Notes:

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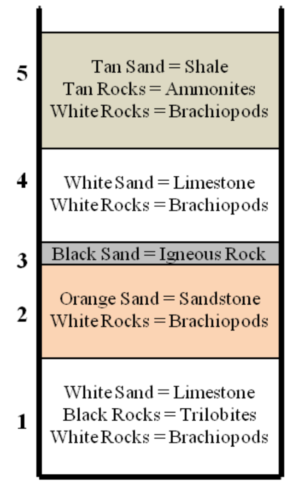
- Types of sedimentary rock include sandstone, limestone, and shale.

- Q. Ask for a show of hands of which students have seen rock layers on the sides of the highway while driving around Nashville – this is sedimentary rock! Ask if anyone knows what type of rock this is.
  - *Limestone*
- Tell students that we are going to create a model of sedimentary rock layers.

B. Creating a Model of Sedimentary Layers

- Set up at the front of the class the apparatus to create the sedimentary rock column demonstration
  Materials for VSVS demo
  1 plate
  1 column container
  1 bottle of water
  1 set of numbered jars of sand, with different colors of sand representing different types of sedimentary rock and different stones representing fossils:
    - Jar 1: White sand containing black and white stones.
    - Jar 2: Orange sand containing white stones.
    - Jar 3: Black sand.
    - Jar 4: White sand containing white stones.
    - Jar 5: Tan sand containing white and tan/red stones.



Materials for students, per group:
1 plate, 1 column containers (jars containing water), 1 set of jars of sand (1-5, to represent different types of rocks):
36 observation sheets
20 Handouts with Column Diagram,

- One VSVS member should draw a large diagram on the board to represent the column, based on the diagram on this page.
  - Do not draw the entire finished diagram. Start with the open-top rectangle representing the column (bolder lines). As each jar of sand is added, draw the layer line and write the color of the sand and rocks.
- The other VSVS members should hand out the columns (jar), jars of sand, water, and plates (1 per group of students).
  Put the column on the plate to catch spills.

- Demonstrate how to create the column and have the students do each layer after you do.
  1. Pour the container of water into the column, reminding students that sedimentary rocks form when sediments settle out of water and form layers.

  2. Explain to students that we are using different colors of sand to represent different types of sedimentary rock, and different color stones to represent fossils. **Point out that the fossils (stones) get deposited at the same time as the sand and rocks.**

  3. Pour all of the sand and rocks from container #1 into the column. <u>Wait until each layer settles (~30 seconds) before pouring the next</u> layer. Make sure students are adding the jars of sand to the column in the correct order (#1 first ...)

Your Notes:

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4. When settled, pour all of container #2's contents into the column and wait for it to settle. Then container #3's contents, and so forth until all 5 containers are used. Make sure to update the drawing on the board as new layers are added.

C. Explaining the Column

- Q. Ask students to describe what happened when they poured each layer of sand.
    - *Sand settles through the water to make a flat layer at the bottom of the column.*
    - This is similar to sediment settling out of water to form layers; over millions of years the sediment is compressed and turns into rock.
    - Explain that sediment is deposited in horizontal layers, and it stays that way unless something disturbs it.
    - Have students answer Question 1 on their observation sheet.
        1. *Sediments settle and form rocks in ___**horizontal**_layers.*

    - **Fossils are deposited at the same time the rock material is deposited. Therefore the ages of the fossil and rock in which it is found are the same.**
    - Have students answer Question 2 on their observation sheet.
        2. *What is the age of a fossil relative to the rock in which it is found?* ***The same_***

- Tell students to imagine that the process of creating their sand columns took millions of years to occur.
- Tell students that different rock layers represent different periods of time.
    - Q. Ask students which layer is the oldest in the column.
        - *The bottom layer; it was deposited first and other layers were deposited on top of it.*
    - Q. Ask students which layer is the youngest in the column.
        - *The top layer; it was deposited last, on top of all other layers.*
    - How old are the middle layers? *(You can't tell for sure! But they are older than the top layer and younger than the bottom layer.)*
    - Have students answer Question 3 on their observation sheet.
      *#3. Older layers are **__at the bottom_** in a column of sedimentary layers, while younger layers **__are at the top__.***
    - Fossils succeed each other in a definite order – the oldest fossils in a series of layers will be in the lowest layer.

D. Index Fossils and Radioactive Dating

Learning goals:
- **Students observe a model of a stratigraphic column that includes fossils.**
- **Students correlate the model with the sedimentary column that they created.**
- **Students learn what an index fossil is and realize that in the model, the ammonites and trilobites are index fossils. Index fossils are used for dating rock layers.**
- **Students learn that radioactive elements are used for dating rock layers.**

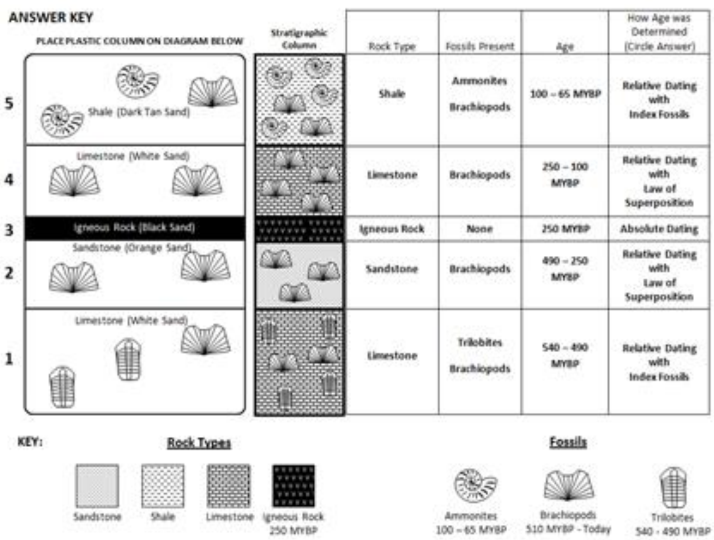
Pass out 1 model of rock layers/fossils encased in boxes plus the "Column Analysis" worksheet to each group of students. Have them hold the model beside their sand column and tell them that the model has

Your Notes:

the same pattern of layers from the sand column. The fossils in the box model are real and are represented by different colored pebbles in their columns

- Explain that the second column (called **Stratigraphic Column**) on the worksheet is the way geologists would represent such a column and that the key on the bottom of the page shows what each symbol means.

- Tell students names of type of rock and fossils in each layer.
    - *Top layer: ammonites and brachiopods in shale*
    - *Bottom layer: trilobites in limestone*
    - *Middle layers 2 and 4: brachiopods in limestone or sandstone*
    - *Middle #3: Igneous rocks*
- Tell students that fossils are often incorporated into sedimentary rocks. The sediment that buries them later forms into rocks with the fossils inside.



Using Index Fossils to find the Age of Rock Layers

- Tell students that in real sedimentary rocks, some fossils are found in many layers, while some are found in only one layer.
    - Q. Ask students which type of fossil, one found in many layers or one found in only one layer, would be more useful for identifying the age of a rock layer. (A tough question – give them hints and walk them to the answer if necessary!)
        A. *Fossils found only in one rock layer can be used for identifying the age of the rock layer. If a fossil is found in many different layers, the age of the layers can't be identified using fossils.*

- Tell students that fossils that are only found in one layer, can be used for identification/rock dating purposes. These fossils are called **index fossils**.
- Have the students answer Question 4 on their observation sheet.
    *#4. **__Index fossils__**are fossils found in only 1 layer of sedimentary rock and can be used for identification/rock dating purposes.*

Your Notes:

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- Q. Ask students which fossil(s) in their column would be considered index fossils, and which would not be considered index fossil(s)

  A. Ammonites and trilobites are only found in one layer, so they would be considered index fossils; brachiopods are found in all layers, so the brachiopod is not an index fossil.

Using Absolute Dating with Radioactive Elements to find the Age of Rock Layers

Tell students to look at layer # 3 in their column – the thin black layer.

A. When there is a dark, skinny layer in a sedimentary rock column, it is usually the result of lava or volcanic ash interrupting a sedimentary rock layer – it is an igneous rock, not a sedimentary rock.

B. Igneous rocks contain radioactive elements like uranium, rubidium, thorium, and potassium – scientists can use these elements to determine the exact age of these rocks.

E. Finding the Ages of the Layers in our Column

Learning Goals: Students will determine the ages of the layers in the model.

- Tell students they are now going to use their model to determine the ages of the "rock" layers. As they go through the column, layer-by-layer, point out what rock types and fossils are represented in the columns. The answers for the rock types and fossils are already given on the worksheet. The students will be asked to determine the ages (relative or absolute) of each layer.

A. The black layer (third layer from the top) is an <u>igneous rock</u>.

How can we find the age of this layer?

*By using **absolute dating** with radioactive elements.*

In this hypothetical case, we will say that this layer is **250 million** years old.

Tell students to enter this data on their worksheet.

- Ask students how an igneous rock might get into a sedimentary layer?
  - Answers should include **volcanic ash** settling out many miles away from an erupting volcano, **lava flows** above ground, or **magma** intruding into rock layers below the surface.

For VSVS Information only:
Most igneous rocks can be dated radiometrically because they contain unstable radioactive elements that decay.
Carbon-14, uranium-238, rubidium-87, thorium, potassium are the most common (isotopic) elements studied.
Igneous rocks can be given a **numerical age** by radiometric dating methods.

Two layers contain index fossils. Which layers are these?

The tan layer (on top) and the white layer on the bottom both contain fossils that aren't found in any other layers. *Ammonites and Trilobites are index fossils and scientists know how old they are (over a range of time).*

So how can we find the ages of these layers?

Ammonites (in the tan layer on top) lived from 100 million years ago until 65 million years ago – this is the range in which this rock was deposited in.

Your Notes:

Tell students to enter this data for the top layer (100-65 MY old, and circle Relative dating with index fossils).

Trilobites (in the white layer on bottom) lived from 540 million years ago until 490 million years ago – this is the range in which this rock was deposited in.

Tell students to enter this data for the bottom layer (540 - 490 MY old, and circle Relative dating with index fossils).

How do we find the dates the other two layers were deposited in?

Relative dating.

We know that the white layer second from the top must have been deposited between the top layer (100 million years ago) and the third layer (250 million years ago)

The orange layer (fourth from the top) must have been deposited between the bottom layer (490 million years ago) and the third layer (250 million years ago).

Tell students to enter this data for layers 2 and 4.

II. Stratigraphy (Correlating Columns)

Learning Goals:
Students look at real life example of stratigraphic columns in 3 National Parks
Students learn how geologists can correlate sedimentary layers many miles apart.

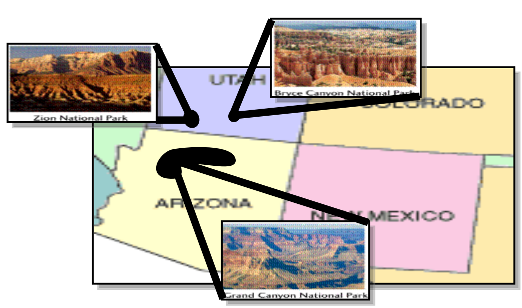
- Tell students that sedimentary rock layers often stretch across entire continents. Sometimes these layers are connected; however, often layers have been removed in some locations by erosion, and some are buried under other layers and can't be seen by us yet.

A. National Park Rock Sequences

- Pass out a set of colored stratigraphic columns (paper-clipped together) to students.

- Tell students that these columns represent actual sedimentary layers taken from the National Parks (Graphic A); they have been cut from the stratigraphic columns in Graphic B, on Handout #1.)
    - Have students separate the columns and put them at their correct National Park locations on the map (Graphic A) in Handout #1. Tell them that although erosion has affected each location differently, they all still show some of the same layers. Have the students put them in stratigraphic order, then place them on the map.
    - Point out that columns can correlate over large distances.
    - Have them put the complete, paper-clipped columns back together and collect them from the students.

Map of National Parks (Graphic A)



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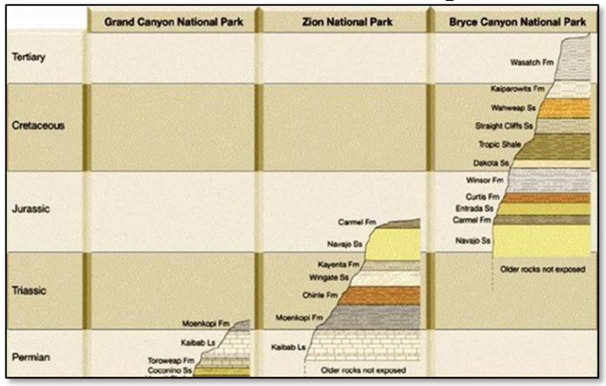
National Park Correlations (Graphic B)



B. Correlating Stratigraphic Columns

- Pass out the set of 3 stratigraphic sequences to each student. Tell students to imagine that these are 3 sequences of rocks found in different places around the US.
  - Tell students to find in sequences A and B at least 2 layers whose index fossils and rock types match.
  - Emphasize that the depth of the layers does not have to be the same.
  - Students should place the sequences side-by-side with matching layers touching.
  - Have them repeat the process with sequences B and C.
  - This can get tricky, so VSVS members should walk around and help students with the task.

- Pass out the longer laminated strip (1 per pair) and tell the students that this geological column is the one they have just compiled from their short sequences. This can tell us a lot more about the geologic history of the earth than the individual columns can.
- Q. Which short strip has the oldest rocks exposed and how do we know?
  - *Location A, because it contains the oldest fossils and has the bottom layers in the geological columns*.
  - These layers still exist at locations B and C, they just haven't been exposed yet.
- Q. Which short strip has the youngest rocks exposed and how do we know?
  - *Location C, because it has the top layers in the geological column*.
  - These layers are missing at locations A and B because of erosion.

VSVS members should collect the columns and answer any questions the students have.

III. Timeline of the Earth (If time permits – do as much as time allows)

Learning Goals: Students can "see" the time scale of earth's history from a model.

A. Introduction

- Q. Ask the class if anyone knows how old the earth is.
  - *4.6 billion years old, or 4600 million years old. Write the number out in full on the board so they understand how much time this is (4,600,000,000).*

Your Notes:

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- Tell students that the timeline of earth's history is called the geologic time scale. We will show them a rope that represents, to scale, this timeline.
- It is divided into 4 major periods called eons, which are further divided into eras. The boundaries between geological times correlate with major changes on earth.

B. Time Scale Model

Tell students to look at the timeline on the observation sheet

- Hold up the time scale model (the cylinder) with just a small piece of string pulled out so that all students can see it. Tell students:
    - The string represents the timeline of the earth's history – the complete geologic time scale over its entire duration of 4.6 billion years.
    - The string is divided into the 4 eons, and the last eon is divided into eras.

Note – the string is 19 feet long, so make sure you have enough room to "spread".

- One VSVS member or student volunteer will hold the string and another will hold the container and walk to the right while removing each eon and stopping when a knot is reached.
- A VSVS member will describe each eon to the students, while another writes the information regarding each eon and era on the board as they are introduced.
- The string must be kept taught in a straight line so that the students get the concept of the length of time taken for each eon.

- **Hadeon Eon**
    - Pull the first (<u>camouflage-colored</u>) section of the string out, and stop as soon as you get to the first knot (between color changes). Tell students:
    - This is the **Hadeon Eon**, from 4.6-3.8 billion years ago.
    - No living organisms during this time, but the oldest known rocks existed (found in the Canadian Rocky Mountains).

Eon:	Hadean Eon	Archean Eon	Proterozoic Eon	Phanerozoic Eon
Years:	4.6-3.8 billion years ago	3.8-2.5 billion years ago	2.5 billion years ago - 540 million years ago	540 million years ago - now
Major Events:	Oldest earth rocks form	Single-cell organisms evolve	Multi-cell organisms evolve	Advanced organisms like plants, mammals, and fish

Era:	Paleozoic Era	Mesozoic Era	Cenozoic Era
Dominant Organisms:	Invertebrates (trilobites, crinoids, ammonites, brachiopods)	Dinosaurs, birds	Mammals

Archean Eon

- Pull the second (<u>tan</u>) segment of the string until the second knot is reached. Tell students:
    - This is the **Archean Eon**, from 3.8-2.5 billion years ago.
    - The first single-cellular organisms lived during this time (fossils found in Australia).

Proterozoic Eon

- Pull the third (<u>white</u>) segment of the string until the third knot is reached. Tell students:
    - This is the **Proterozoic Eon**, from 2.5 billion years ago to 540 million years ago.
    - The first multi-cellular organisms lived during this time (fossils found in Michigan)

Phanerozoic Eon,

Your Notes:

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- Pull out and display the <u>black</u> end of the string. Tell students:
  - This is the **Phanerozoic Eon**, from 540 million years ago to now.
  - Plants, fish, and animals came to exist as we know them today during this time.
  - This last eon is subdivided into 3 smaller time intervals called **eras**.

C. Looking at the Phanerozoic Eon Timeline

- Tell students to look at the Phanerozoic Eon time line. Focus students' attention on the black (Phanerozoic Eon) section of the rope.
  - The different colors (pink, green and yellow) show the different **eras**. The colored string twisted around the black cord corresponds with these eras on the placemat.
  - The organisms shown lived and thrived on earth during the time periods their boxes overlap with; both fossil and living pictures are displayed.

- Tell students that each era ends with the extinction of a large amount of animals on earth.
  - Q. Ask students if they know what extinction means.
    - *When the last remaining members of a species have died out*.

- Point to the <u>pink</u> section of the timescale, and identify it as the **Paleozoic Era**. Tell students:
  - Simple animals called invertebrates dominated the earth in this era. Pictures of different types of invertebrates (trilobites, ammonites, crinoids, and brachiopods) can be seen on the timeline; point them out to the students**. Emphasize that the earliest trilobite is an index fossil.**
  - Early fish, land plants, and reptiles develop but are not common yet.
  - 90% of all species of animals went extinct at the end of this era. (Emphasize to students the magnitude of this extinction – tell them to imagine 90% of animals on earth dying.) (If students ask why – scientists are still investigating!)

- Point to the <u>green</u> section of the timescale, and identify it as the **Mesozoic Era**. Tell students:
  - Dinosaurs and other reptiles dominated the earth in this era.
  - Small mammals, birds, flowering plants, and flies also were common
  - 50% of all species of animals went extinct at the end of this era. (If students ask why, tell them that most scientists agree that it was due to impact of a large meteorite near Mexico.)
  - **The later ammonites are index fossils**

- Point to the <u>yellow</u> section of the time scale as the **Cenozoic Era**. Tell students:
  - This era continues up until today
    Mammals dominate the earth in this era.
  - Q. Ask students if they've thought about how long humans have existed in the geologic time scale. *Humans have only existed in the very last knot of the rope (the dangling skeleton). This is an extremely short time in the history of the earth.*

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We gratefully acknowledge the assistance of Dr. Molly Miller, Professor Emeritus of Earth & Environmental Sciences, Vanderbilt University.
Reference:Chernicoff, S., & Whitney, D. (2007). *Geology: An Introduction to Physical Geology*. Upper Saddle River, New Jersey: Pearson

Your Notes:

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Stratigraphy Observation Sheet

1. Sediments settle and form rocks in ___________________ layers.

2. What is the age of a fossil relative to the rock in which it is found? __________

3. Older layers are ______________________ in a column of sedimentary layers, while younger layers are ________________________.

4. _____________________ are fossils found in only 1 layer of sedimentary rock that is used for identification/rock dating purpose

Eon:	Hadean Eon	Archean Eon	Proterozoic Eon	**Phanerozoic Eon**
Years:	4.6-3.8 billion years ago	3.8-2.5 billion years ago	2.5 billion years ago – million years ago	540 million years ago – mow
Major Events:				

Expansion of Phanerozoic Eon:

Era:	Paleozoic Era	Mesozoic Era	Cenozoic Era
Dominant Organisms:			

Stratigraphy - Answers - Observation Sheet

1. Sediments settle and form rocks in _**horizontal**__________________ layers.

2. What is the age of a fossil relative to the rock in which it is found? **The same.**__________

3.Older layers are **at the bottom** in a column of sedimentary layers, while younger layers **are at the top.**

4.. __**Index fossils**__ are fossils found in only 1 layer of sedimentary rock that is used for identification/rock dating purpose

Eon:	**Hadean Eon**	**Archean Eon**	**Proterozoic Eon**	**Phanerozoic Eon**
Years:	4.6-3.8 billion years ago	3.8-2.5 billion years ago	2.5 billion years ago - 540 million years ago	540 million years ago - now
Major Events:	Oldest earth rocks form	Single-cell organisms evolve	Multi-cell organisms evolve	Advanced organisms like plants, mammals, and fish

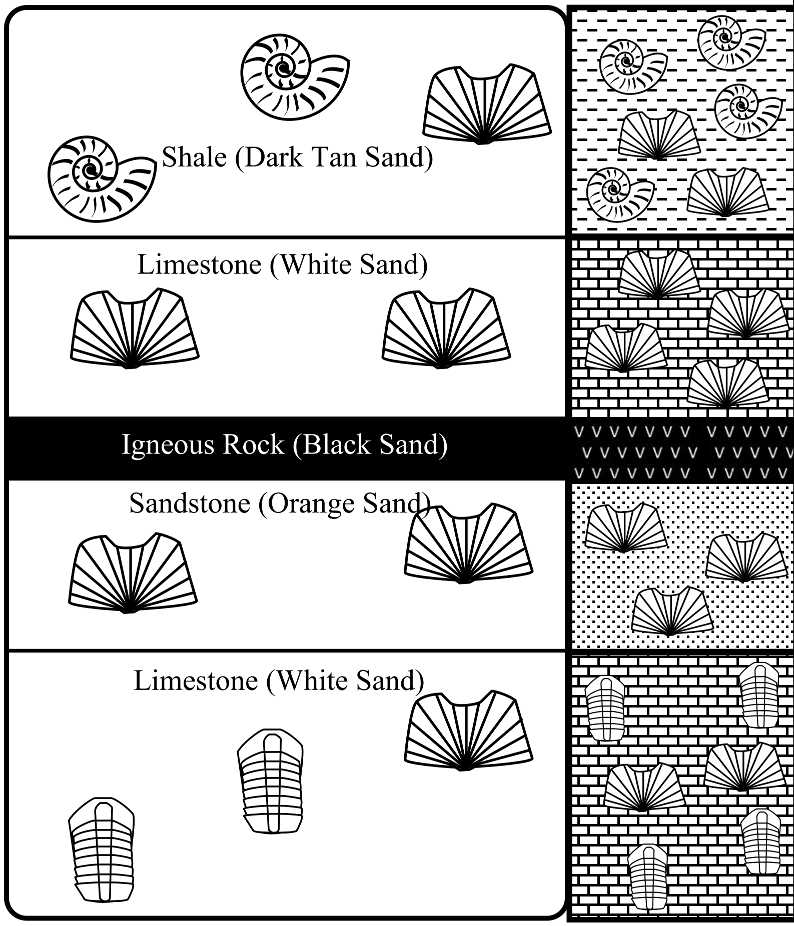
Era:	**Paleozoic Era**	**Mesozoic Era**	**Cenozoic Era**
Dominant Organisms:	Invertebrates (trilobites, crinoids, ammonites, brachiopods)	Dinosaurs, birds	Mammals

ANSWER KEY

PLACE PLASTIC COLUMN ON DIAGRAM BELOW

Stratigraphic Column

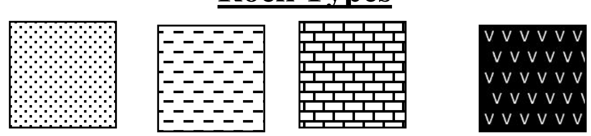
5
4
3
2
1



Rock Type	Fossils Present	Age	How Age was Determined (Circle Answer)
Shale	Ammonites Brachiopods	100 – 65 MYBP	Relative Dating with Index Fossils
Limestone	Brachiopods	250 – 100 MYBP	Relative Dating
Igneous Rock	None	250 MYBP	Absolute Dating
Sandstone	Brachiopods	490 – 250 MYBP	Relative Dating
Limestone	Trilobites Brachiopods	540 – 490 MYBP	Relative Dating with Index Fossils

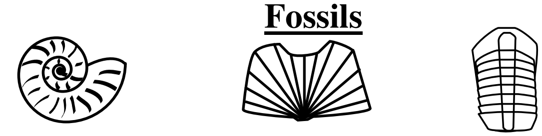
KEY:

Rock Types



Sandstone
Shale
Limestone
Igneous Rock 250 MYBP

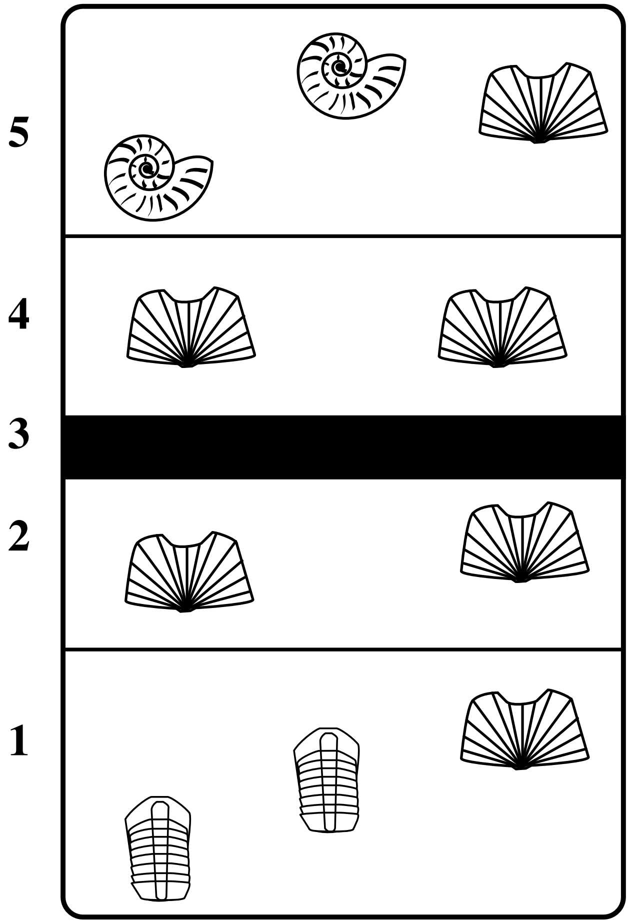
Fossils



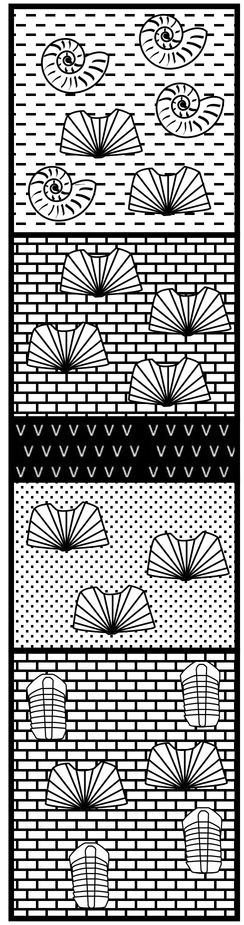
Ammonites 100 – 65 MYBP
Brachiopods 510 MYBP - Today

Name ______________________________________

PLACE PLASTIC COLUMN ON DIAGRAM BELOW



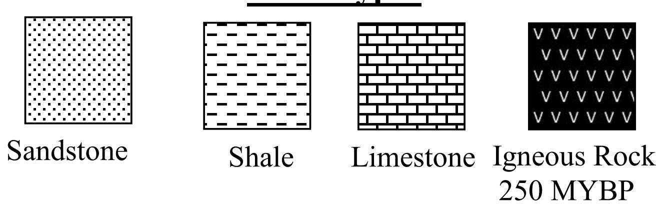
Stratigraphic Column



Rock Type	Fossils Present	Age	How Age was Determined (Circle Answer)
Shale	Ammonites Brachiopods		Absolute Dating (Radiometric) Relative Dating with Index Fossils Relative Dating
Limestone	Brachiopods		Absolute Dating (Radiometric) Relative Dating with Index Fossils Relative Dating
Igneous Rock	None		**Absolute Dating**
Sandstone	Brachiopods		Absolute Dating (Radiometric) Relative Dating with Index Fossils Relative Dating
Limestone	Trilobites Brachiopods		Absolute Dating (Radiometric) Relative Dating with Index Fossils Relative Dating

KEY:

Rock Types



Fossils