VOLUNTEER INFORMATION
Team Member Contact Information

Name: ____________________________________ Phone Number: __________________________

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 Director: Pat Tellinghuisen
patricia.c.tellinghuisen@vanderbilt.edu

615-343-4379 (W), 615-297-5809 (H)

VSVS Office: Stevenson Center 5234

Co-Presidents: Christina Wang
christina.e.wang@vanderbilt.edu
Arunabh Singh
arunabh.singh@vanderbilt.edu

Secretaries: Gabriela Gallego
gabriela.l.gallego@vanderbilt.edu
Sabeen Rehman
sabeen.rehman@vanderbilt.edu

Vanderbilt Protection of Minors Policy: As required by the Protection of Minors Policy, VS VS 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://studentorgs.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 Pat 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 VS VS Lab, Stevenson Center 5234.
▪ The VS VS Lab is open 8:30am – 4:00pm (earlier if you need dry ice or liquid N₂).
▪ 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

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#### Activities
- **Team Leader Training**
- **Team Training Mini Lesson for Tues, Wed, Thurs Teams**
- **Week 1 for Tues, Wed, Thurs Teams**
- **Team Training for Tues, Wed, Thurs Teams**

### MARCH

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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_Co

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

HEAD MAGNET SCHOOL: 1830 JO JOHNSON AVE
The parking lot on the left to the Johnston Ave.

J.T. MOORE MIDDLE SCHOOL: 4425 GRANNY WHITE PIKE
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: 417 RAMSEY STREET
Going down Ramsey Street, Meigs is on the left.

ROSE PARK MAGNET SCHOOL: 1025 9th AVE SOUTH
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
Parking is beside the soccer field, or anywhere you can find a place. Enter through the side door.

EAST LITERATURE MAGNET SCHOOL: 110 GALLATIN AVE
Going down Gallatin Avenue, East Literature Magnet School is on the left.

MARGARET ALLEN MIDDLE SCHOOL: 500 SPENCE LN
From West End down Broadway, take 1-40E to exit 212 Rundle Ave. Left on Elm Hill to Spence Lane.
GOAL: To demonstrate how an epidemic spreads and how the carrier is identified.

VSVSer

LESSON OUTLINE

1. Introduction Discuss disease and epidemics.
2. Explanation of Steps Scientists Follow to Test for a Disease
   Discuss the four steps. Explain indicators and the use of sodium hydroxide to represent the disease-causing organism.
3. Testing for a Disease - Learning to Read Positive and Negative Controls
   Students use phenolphthalein (feen-ol-thail-een) and sodium hydroxide to represent a positive control test. In terms of an epidemic, the pink color indicates the sample is from an "infected" individual, and no color indicates no infection.
4. How Does the Disease Spread?
   Eight student volunteers are used to demonstrate how a disease spreads
5. The Disease Spreads – Epidemic!
   The results of the spreading disease will not be correct if the procedure is not followed carefully. You will need to fill enough 3.5 oz cups about half-full of water so each student AND VSVSers has one (except for VSVSer who gets the NaOH cup). Also pour NaOH in another 3.5 oz cup about 1/3 full, making sure students do not see you do this. Keep this cup separated from the others and be sure a VSVS volunteer gets this cup. This person will later be identified as patient zero. You will need an even number of participants for this activity so use all classroom students, the teacher, and as many VSVS volunteers as possible to have an even number. Participants pour a small amount into a 1 oz cup as a control. Before starting the exchanges, participants (including VSVSers) write their names on the Observation Sheet. A participant then picks another student to exchange with - writing the name down on the "Exchange 1" line. One of the persons pours all of the liquid into the second person’s cup. Then the second person pours half of the liquid back into the first person’s cup. Students and VSVSers MUST walk to another part of the room before proceeding with the 2nd exchange (otherwise the “infected” cups will be isolated to a small group of friends. The exchange procedure is followed two more times with two additional persons.
6. Identifying Patient Zero - The Carrier
   Follow the steps to identify patient zero for the group.
7. The Cure
   Have the participants with "infected" samples bring their samples to the front of the room. Add a few drops of 0.2 M HCl to give a clear solution.
8. Topics for Discussion

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.
PRE-LESSON SET-UPS

Write the following vocabulary words on the board:
epidemic, bacteria, viruses, protists, prions, indicator, carrier.
Refer to these words as you encounter them.

For Part III: Testing for a Disease

Materials Needed For Each Pair of students
1 2 oz bottle labeled. “Uninfected” – water
1 2 oz bottle labeled. “Infected” – sodium hydroxide
1 1 oz dropper bottles of phenolphthalein
1 2 oz cup labeled “Uninfected”
1 2 oz cup labeled “Infected”
1 Instruction Sheet
2 Observation Sheets

For Part IV:
Place 8 1oz cups on top of the laminated numbers (1-8).
Pour water (1/3rd fill) into cups numbered 1-7
Pour 0.025 M NaOH (1/3rd fill) into cup #8

For Part V:
You will need to fill enough 3.5 oz cups about 1/3rd full of water so all students plus VSVSers have one (except for one VSVSer who gets the NaOH cup).
Fill (1/3rd) another 3.5 oz cup with NaOH, making sure students do not see you do this. Keep this cup separated from the others and be sure a VSVS volunteer gets this cup. This person will later be identified as patient zero.
You will need an even number of participants for this activity so use all classroom students, the teacher, and as many VSVS volunteers as possible to have an even number.

I. INTRODUCTION

Learning Goals: Students identify important parts of an epidemic and can provide a simple explanation of how a disease spreads throughout a population

This lesson allows the class to participate in a "mock" epidemic that spreads throughout the class undetected. Afterwards, the class will use an indicator to determine who was the carrier, who has been "infected”, and how the disease spread.

Why is the science in this lesson important?
A few years ago, the Ebola virus swept across West Africa and around the world, affecting millions of people. Many people wondered how it spread so quickly. Scientists at the CDC called epidemiologists study the spread of disease by looking at possible causes and create strategies to contain it. They are critical in maintaining global health and treatment of infectious diseases.

Ask the students what causes a disease.
Accept their responses and discuss as needed.
The following information may be helpful to you in this discussion.
• Bacteria, viruses, protists, and prions can all cause diseases. (Students may group all of these under the heading "germs").

Your Notes: 2
**Bacteria:** Strep throat is an example of a disease caused by a bacterium. Bacteria are one-celled microscopic organisms. Although most bacteria are harmless to humans, some bacteria are harmful and produce disease in a number of ways. For example, tuberculosis is caused by a bacterium that grows in the tissues of the lungs. As the bacterium multiplies, it kills surrounding cells and makes it difficult to breathe.

**Virus:** AIDS and the flu are examples of diseases caused by a virus. A virus is a large molecular framework that includes a protein coating that surrounds the DNA or RNA that contains the genetic information for the virus. Viruses cause many other infectious diseases, such as measles, chicken pox, and mononucleosis.

**Protist:** Malaria is an example of a disease caused by a protist. The protist is housed in the mosquito’s salivary glands. When an infected mosquito bites a person the protist crawls into the blood stream and infects that person. (Mosquitoes that carry malaria are prevalent in the tropics, not in Nashville.)

**Prion:** “Mad Cow’s Disease” is caused by a prion. This single protein, discovered in 1993, causes the crystallization of proteins in the nervous system, which can lead to death. The discovery that proteins alone can transmit an infectious disease came as a considerable surprise to the scientific community. Scientists did not expect diseases to be caused by anything smaller than a virus.

Ask the students what they know about epidemics. Accept their responses and discuss as needed.

The following information may be helpful to you in this discussion.

- An epidemic is a disease that has spread to a large number of people.
- Several famous epidemics in history are the bubonic plague, smallpox, AIDS tuberculosis, Ebola.
- Smallpox, caused by a virus, was the leading cause of death in many countries and is believed to have killed 90% of the American Indians. Now there are vaccinations for smallpox and the smallpox virus is believed to be under control.
- Tuberculosis (known as the "white plague") killed 1 in 5 people.
- The bubonic plague (known as the "black death") killed half the people in Europe and Asia every few centuries. Now this plague is easily cured through medication.
- Students may be familiar with movies such as Outbreak. In Outbreak an epidemic of Ebola virus threatened the United States.

Ask students how a disease or an epidemic spreads. Accept their responses and discuss as needed.

The following information may be helpful to you in this discussion.

- Not all contagious diseases are spread in the same manner.
- Some diseases are spread through the air (airborne) -- the common cold, flu.
- Some diseases are spread through the water (waterborne) -- cholera.
- Some diseases are spread through the exchange of body fluids (saliva, blood) AIDS, Hepatitis, the common cold, flu. Saliva can also be exchanged by eating or drinking after an infected person. To avoid spreading diseases during the cold and flu season, people are strongly encouraged not to eat or drink after each other.

Your Notes: 3
II. EXPLANATION OF STEPS SCIENTISTS FOLLOW TO TEST FOR A DISEASE

Learning Goals:
Students can explain and carry out a controlled process that can be used to test for a disease
Students use a control group to conduct a systematic experiment

Explain the steps scientists follow to test for a disease.
1. When an epidemic breaks out, scientists first try to discover which organism caused the epidemic.
2. Once the organism is identified, scientists develop a way to test for the presence of this organism.
3. Before testing those who may be infected, scientists have to set up positive and negative controls.
   a. A positive control is a sample containing the disease-causing organism.
      (This sample comes from a person who definitely has the disease.)
   b. A negative control is a sample that doesn’t contain the disease-causing organism. (This sample comes from a person who doesn’t have the disease.)
4. Once the test is developed, scientists do three things:
   a. Find out how many people are infected.
   b. Determine how the infection spreads (air, water, body fluids).
   c. Identify patient zero (the first carrier - the person that transmitted the disease to a particular group or community).

Explain indicators to students.
When scientists want to determine the presence of a certain substance, they can use a chemical which indicates if that substance is present. The chemical they use is called an indicator.

In the mock epidemic we are doing today, we are going to use sodium hydroxide as the disease-causing organism. In real life, sodium hydroxide has nothing to do with diseases, but is a chemical that is used in the lab. It is useful in this experiment because it can be detected by an indicator called phenolphthalein (feen-ol-thail-een).

When phenolphthalein is added to a solution containing sodium hydroxide, the solution will turn red or pink. If sodium hydroxide is not present, then there will be no color change.

Tell the students that they are going to receive two samples, one containing sodium hydroxide, and one containing water. They will use phenolphthalein as an indicator to determine which sample contains the sodium hydroxide.
III. TESTING FOR A DISEASE - LEARNING POSITIVE AND NEGATIVE CONTROLS

Learning Goals:
Students can explain and carry out a controlled process that can be used to test for a disease
Students use a control group to conduct a systematic experiment

Divide the class into pairs of students.
Materials Needed For Each Pair of students
1  2 oz bottle labeled. “Uninfected” – water
1 2 oz bottle labeled. “Infected” – sodium hydroxide
1 1 oz dropper bottles of phenolphthalein
1 2 oz cup labeled “Uninfected”
1 2 oz cup labeled “Infected”
1  Instruction Sheet
2  Observation Sheets
Give each pair the materials listed above.
Note: A VSVS team member will still need to give instructions, but the students can refer back to the instruction sheet as they are doing the experiments. You will still need to guide them through the procedures, making sure they understand the instructions.
Tell students to:
1. Empty the liquid in the “Uninfected” bottle into the cup labelled “Uninfected”.
2. Empty the liquid in the “Infected” bottle into the cup labeled “Infected”.
3. Examine the two liquids to see if they can tell the difference between the two, and record their observations. [They should not be able to see a difference.]
4. Members of the VSVS team should walk around to add 1-2 drops of the indicator phenolphthalein to each cup, and the students will record their observations. The cup with water should stay clear while the cup containing sodium hydroxide (“infected”) should turn pink indicating the presence of a base (the infection).
   For our purposes, this pink color will indicate that the sample is from an “infected” individual.

Lead students to the conclusion that:
In the case of the cup with the sodium hydroxide, the infection is present, making it a positive control test. Now we know that whenever we add phenolphthalein and the solution turns pink, then an infection is present. In terms of this epidemic, the pink color indicates that the sample is infected with the disease.

The cup containing only water did not change color (and was therefore a negative control test). Now we know that whenever we add phenolphthalein and the solution does not turn pink, there is no infection present. In terms of the epidemic, the clear color indicates that the person is not infected with the disease.

Note: Leave the cups with phenolphthalein on the students’ desks to use for comparison later.

Your Notes: 5
IV. HOW DOES THE DISEASE SPREAD AND BECOME AN EPIDEMIC?

**Learning Goals:** Students identify important parts of an epidemic and can provide a simple explanation of how a disease spreads throughout a population

Materials Needed For Each Class:
- 8 clear 1 oz plastic cups
- 8 laminated numbers (1-8)
- 1 Bottle of 0.025 M NaOH
- 1 dropper bottle of phenolphthalein
- 1 chart on the board (copy chart given below on board)
- 1 bottle of water

This should have been done in pre-setup:
- Place the clear 1 oz plastic cups on top of the laminated numbers 1-8.
  - 1/3 filled cups 1-7 with water.
  - 1/3 filled cup 8 with NaOH.

A VSVS member should do the following:
1. Copy the Exchange Sequence chart (below) on the board.

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<th>First Exchange</th>
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<td>Volunteer 1 with Volunteer 5</td>
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<td>Volunteer 2 with Volunteer 7</td>
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<td>Volunteer 3 with Volunteer 6</td>
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<tr>
<td>Volunteer 4 with Volunteer 8</td>
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2. Select **SIX student** volunteers and ask them to come to the front of the room. **MAKE SURE THE VOLUNTEERS ARE WILLING TO HAVE AN “INFECTED” SAMPLE.** Explain to the students that when you refer to a person being infected, you mean the sample that they are holding, NOT the person holding the sample.

3. Use **TWO VSVS members**, to make a total of 8 volunteers in the lineup.
4. **ONE of the VSVS volunteers MUST take the cup #8.** This is the infected cup.
5. As the students come to the front, hand them one of the cups containing a liquid and the corresponding numbered tag.
6. Have the students and 2 VSVS members place the tag around their necks. Ask them to face the class and hold the cups so the class can see them.
7. Have the 8 volunteers look at the chart on the board to see what persons they will be exchanging with for their 1st exchange. The first Exchange is 1 with 5, 2 with 7, 3 with 6, 4 with 8.
8. Tell the volunteers that when you say the word exchange, the first person should pour all of the liquid into the second person’s cup. The second person pours half of the liquid back into the first person’s cup. **Use volunteers holding cups 1 and 5 to demonstrate this.**
9. When all eight are ready, say "exchange” and allow the 1st exchange to occur.
10. Then have the 8 volunteers line up in numerical order in front of the class.

Your Notes: 6
Tell the class that you know who the 1st carrier of the infection is - #8 (one of the VSVS members).
Ask the class to look at the exchanges listed on the board and tell which students cups should now be infected.
Add the indicator (phenolphthalein) to each of the eight cups to determine if the students were correct. Circle the numbers of the infected samples on the chart.
Note: The two volunteers’ samples that are “infected” (pink color) are 4 and 8.

Tell the volunteers they are going to continue to spread the infection. Tell the students to look at the 2nd exchange chart and predict who will get infected. Tell the volunteers to do a second exchange by following the 2nd sequence.

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<th>Second Exchange Sequence</th>
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<td>Volunteer #1 with Volunteer #2</td>
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<td>Volunteer #3 with Volunteer #8</td>
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<td>Volunteer #4 with Volunteer #7</td>
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<td>Volunteer #5 with Volunteer #6</td>
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Ask the students: At the end of the 2nd exchange, how many volunteers are now infected? [4] (#’s 4, 8, 3 and 7 will all now be pink.)
In general, the number of people infected doubles with each exchange.
Based on this mathematical concept, ask the class how many exchanges it would take for one person to infect a classroom of 30. [30 people are infected in 5 exchanges: first exchange - 2, second exchange - 4, third exchange - 8, fourth exchange - 16, fifth exchange - 32]

Note: Dispose of all liquids in waste container or sink.

V. THE DISEASE SPREADS - EPIDEMIC!!!!!!!!!!!!

Learning Goals: Students identify important parts of an epidemic and can provide a simple explanation of how a disease spreads throughout a population

Materials needed per student:
1 3.5 oz cup 1/3 filled with water
1 1 oz cup
1 pencil per student (have students use their classroom pencils)

Materials needed for VSVS members
4 dropper bottles of phenolphthalein (from previous experiment)
1 3.5oz cup containing NaOH (for VSVS member to use in the exchanges.)

Note: If you did not fill enough of the 3.5 oz cups half-full of water before the lesson began, do it now. Be sure that the students do not observe you when you pour the NaOH solution from the plastic bottle into the cup for a VSVS volunteer. Keep this cup separated from the

Your Notes: 7
others and be sure a VSVS volunteer gets this cup. This person will later be identified as patient zero.

- You need an even number of participants in this activity, so use all classroom students, the teacher, and as many VSVS volunteers as possible while maintaining an even number.
- One participant (a VSVS volunteer) will have a cup containing NaOH solution. (Don’t tell the students who has this cup since they will be trying to identify this person at the end of the activity.) This person is patient zero - the person who introduces the disease to the community (classroom) by an outside host (VSVS volunteer). This will also eliminate any possible stigma that one of the classroom students might feel if he/she is identified as patient zero.

1. Give each participant a 3.5 oz. cup that is 1/3rd-filled with water. (Remember one VSVS volunteer has the cup with the NaOH solution.)

2. Give each participant a 1 oz. cup. Really Really Important: Have participants pour a small amount of their liquid into this 1 oz. cup and set it on their desks until the end of the activity. This "uncontaminated" liquid will be the control and will not be exchanged. This liquid may be needed at the end of the activity to definitely identify patient zero. **Students do not use this liquid until the end of part VII.**

4. Have all participants write their names on the top line of their observation sheet.

5. Have all participants choose a partner, and write the name of that person opposite Exchange 1.

6. When one VSVS volunteer says, "Exchange", one of the persons in each pair should pour all of the liquid in his/her 3.5 oz cup into the second person’s 3.5 oz cup. The second person should pour half of the liquid back into the first person’s cup. Both persons should have recorded the name of the other person beside the words - Exchange 1.

7. After Exchange 1 is finished, tell students (and VSVSers) to move around the class until a VSVS member tells them to stop. It is important that the students do NOT remain seated in their groups, but instead go to another group for the 2nd and 3rd exchanges. If this does not happen, all the contaminated samples will be in a small sub group within the class.

8. Everyone chooses a NEW partner and completes the exchange procedure for Exchange number 2. Tell students to remember to record the name of the new person.

8. Complete Exchange number 3 in a similar manner. All participants should now have 3 names on their observation sheets.

   Exchange 1 Joe
   Exchange 2 Sally
   Exchange 3 Todd

**DO NOT TEST THE LIQUID IN THE 1OZ CUPS YET.**
VI. IDENTIFYING PATIENT ZERO -- THE CARRIER

Learning Goals:  Students can explain and carry out a controlled process that can be used to test for a disease
Students identify important parts of an epidemic and can provide a simple explanation of how a disease spreads throughout a population

Materials Needed:
No new materials are needed for this activity.
3.5 oz. cups, 1 oz. cups, and phenolphthalein from the previous activity will be used.

1. Students, VSVS members and teacher should return to their original places and test the liquid in their 3.5 oz cups by adding 1-2 drops of the indicator, phenolphthalein.
2. Ask all participants with an uninfected (clear color) sample to sit down. Ask all participants with pink solutions to bring their observation sheets and come to the front of the class. They are the ones with infected samples. After 3 exchanges, there should be 8 or fewer infected samples.
3. Ask these participants to bring their 1 oz cup with the original uncontaminated liquid to the front of the room.
4. Add the indicator to the liquid in each of these 1 oz cups. The one that turns pink identifies patient zero.  [The VSVS volunteer should be patient zero!]
Note: Keep the 3.5 oz. cups with the infected samples.

Optional Activity: If time permits, start with patient zero and trace the spread of the disease. Takes 5 to 10 minutes. To trace the spread of the disease, have patient zero stand and ask the person who exchanged with patient zero on the first exchange to stand. Then ask all persons (two more) who exchanged with those standing during the second exchange to stand. Finally, ask all persons (four more) who exchanged with those standing during the third exchange to stand.

VIII. THE CURE

Materials Needed:
1 dropper bottle containing 0.2 M hydrochloric acid, labeled "The Cure"
infected samples from part VI
20 “How Contagious is Measles?” handout

Pass out the Measles handout
1. Ask students how an epidemic can be stopped.
   Accept logical responses. (Medication, shots or vaccines, use of antibodies)
   (If students have seen Outbreak, they may suggest "by bombing the town". If they watch Star Trek: The Next Generation, they may suggest filtering the disease through the use of the transporter.)

2. Tell the students that a scientist has discovered the cure and that you happen to have some with you. (Show the bottle containing O.2 M hydrochloric acid - labeled "The Cure").

3. Ask the "infected" individuals to bring their samples to the front of the room.

4. Add several drops of the "cure" to their samples and allow the class to watch the pink color disappear. (It may be necessary to stir the sample.)

Your Notes: 9
5. Share the following information with the students:
   • Vaccinations are important in preventing epidemics. (polio, chicken pox)
   Tell students to look at the “How contagious is Measles” handout. Ask them if they remember
   the measles outbreak in 2014, when over 600 people were infected with the measles virus. The
   majority of people infected were unvaccinated. Point out how contagious measles is, and why.
   • Passive immunity involves using antibodies from individuals who are resistant to
     infection.

CLEAN-UP
   Dispose of all used liquids in cups and 1 oz cups by pouring them down the sink or into the
   Waste bottle. Return all used cups to VSVS lab in the trash bag. All UNUSED cups should
   be kept separated from used cups.
   Return all bottles to VSVS box in an upright position.

TOPICS FOR DISCUSSION
I. VACCINES and CURES
   • Vaccines prevent people from getting infected; while cures are designed to treat infected
     people.
   • With each new disease that humans face, scientists first try to find ways to cure those who are
     infected and second try to find ways to prevent the disease from spreading to people who are not
     infected. Often different scientists work on these problems simultaneously.
   • In the United States, this work is coordinated through the CDC (Center for Disease Control)
     in Atlanta.
   • Most children receive vaccines for smallpox, polio, and the measles.
   • Animals are also subject to epidemics, so animals are given vaccines for diseases such as
     rabies and feline leukemia.

II. FAMOUS EPIDEMICS
   • Black Plague in Europe
      When Genghis Khan attacked Istanbul in the Middle Ages, the city was well fortified by city
      walls. Several of the men in Genghis Khan’s army died of the black plague. Genghis Khan
      had these dead bodies catapulted over the city walls in an attempt to infect the inhabitants
      with black plague. Many people in the city did get sick with this disease. Several people
      escaped from Istanbul, left Turkey, and carried the epidemic to Europe. As a result, 25% of
      all Europeans died of the black plague.

   • Smallpox in North America
      The Spaniards brought smallpox to North America in the 1500’s. It is estimated that 95% of
      the 20 million Native Americans died from smallpox. The Mayans, Incas, and other Indian
      tribes had no immunity to this disease. Cortez, the Spaniard who led the conquest of the
      Mayans, was a carrier of smallpox. He survived smallpox as a child and bore the scars as an
      adult.

Lesson adapted by Dr. Todd Gary, former Coordinator of VSVS, Vanderbilt University
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Your Notes: 10
EPIDEMIC – Instruction/Observation Sheet

vocabulary words: epidemic, bacteria, viruses, protists, prions, indicator, carrier.

1. Introduction

2. Explanation Of Steps Scientists Follow To Test For A Disease

3. Testing For A Disease - Positive And Negative Controls
   a. Look at the solutions in the 2 cups labelled “uninfected” - water and “infected” – sodium hydroxide.  
      Do they look any different? ______________________________________
   b. Add two drops of the indicator phenolphthalein to each cup.  
      What color is the liquid in the “water” cup? ______________________
      What color is the liquid in the “sodium hydroxide” cup? ______________

4. The Epidemic Spreads
   c. Pour a small amount of liquid from your 3.5oz cup into the 1 oz. cup.
   d. Set it on your desk until the end of the activity. This “uncontaminated” liquid in the 1oz cup is the control and will not be exchanged. This liquid may be needed at the end of the activity to definitely identify patient zero.

Your Name
________________________

First Person’s Name (Exchange 1) __________________________

Second Person’s Name (Exchange 2) __________________________

Third Person’s Name (Exchange 3) __________________________

Return to your original place and test the liquid in your 3.5 oz cup by adding 1-2 drops of the indicator, phenolphthalein.  
   What color is your solution? __________________________
   Is your sample “infected”? __________________________

5. Identifying Patient Zero -- The Carrier
   If you have a solution that is pink, go to the front of the class.
   Ask these participants to bring their 1 oz cup with the original uncontaminated liquid to the front of the room.
   Add the indicator to the liquid in each of these 1 oz cups. The one that turns pink identifies patient zero.

6. The Cure
   The VSVS team will explain this step.
   A VSVS member will add several drops of the "cure” to your sample.
   What happens to the pink color? __________________________
Answer: EPIDEMIC – Instruction/Observation Sheet
vocabulary words: epidemic, bacteria, viruses, protists, prions, indicator, carrier.

6. Introduction

7. Explanation Of Steps Scientists Follow To Test For A Disease

8. Testing For A Disease - Positive And Negative Controls
   e. Look at the solutions in the 2 cups labelled “uninfected”-water and “infected” – sodium hydroxide.
      Do they look any different? No
   f. Add two drops of the indicator phenolphthalein to each cup.
      What color is the liquid in the “water” cup? Clear
      What color is the liquid in the “sodium hydroxide” cup? Pink

9. The Epidemic Spreads
   g. Pour a small amount of liquid from your 3.5oz cup into the 1 oz. cup.
   h. Set it on your desk until the end of the activity. This "uncontaminated" liquid in the 1oz cup is the control and will not be exchanged. This liquid may be needed at the end of the activity to definitely identify patient zero.

Your Name
Joe

First Person’s Name (Exchange 1)
Sally

Second Person’s Name (Exchange 2)
Pat

Third Person’s Name (Exchange 3)
Bill

Return to your original place and test the liquid in your 3.5 oz cup by adding 1-2 drops of the indicator, phenolphthalein.

What color is your solution?
Is your sample “infected”?

10. Identifying Patient Zero -- The Carrier
If you have a solution that is pink, go to the front of the class.
Ask these participants to bring their 1 oz cup with the original uncontaminated liquid to the front of the room.
Add the indicator to the liquid in each of these 1 oz cups. The one that turns pink identifies patient zero.

6. The Cure
The VSVS team will explain this step.
A VSVS member will add several drops of the "cure" to your sample.
What happens to the pink color? disappears
Goal: To introduce students to the types of igneous rocks, how they form, and what minerals combine to form them.

Fits Tennessee Standards
GLE 0707.7.1 Describe the physical properties of minerals
GLE-0707.7.3 Distinguish among sedimentary, igneous, and metamorphic rocks and relate these to a simple diagram of the rock cycle.

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
   C. 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 IIIB, IIIC and IIID and Part III:
16 laminated mats for igneous rocks and 16 Venn diagrams.

For Part IV. Examining Volcanic Rock
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?
Climate change can cause plenty of different extremely impactful changes to happen to the earth. One recent study found that there is a possibility of increased volcanic activity and a decrease in the amount of magma that can be held by the earth's crust. Another important relevant use for geology is dating in evolutionary biology. Geologists can look at ratios of different iron ions to understand atmospheres of the past and when different species evolved to survive in it.

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.
- 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 coarse-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 intermediate 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).

**Pass out the laminated mats for igneous rocks AND the Venn diagram (1 per pair).**

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 **Extrusive Igneous Rocks** that formed from lava on the Earth’s surface. These rocks are fine-grained.
- The bottom row of rocks contains **Intrusive 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.
  - The color gradually gets lighter from left to right.

**Your Notes:**
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
• 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:
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.

![Landscape Diagram](image)

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:**

__________________________________________________________________________________

__________________________________________________________________________________

__________________________________________________________________________________

__________________________________________________________________________________
• 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:
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.
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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Upper Saddle River, New Jersey: Pearson

Your Notes:
Stratovolcanoes

Mt. St. Helens, Washington

Shield volcanoes

Kilauea volcano, Hawaii
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?
   __________________________

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?
   ______________________________________________________
   ______________________________________________________

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?
   ______________________________________________________
   ______________________________________________________

8. Do you think pegmatite is intrusive or extrusive? Why?
   ______________________________________________________
   ______________________________________________________
IV. Examining Volcanic Rock

<table>
<thead>
<tr>
<th>Volcanic Rock:</th>
<th>What do you observe? What makes this rock unique?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicular Basalt (M)</td>
<td></td>
</tr>
<tr>
<td>Scoria (N)</td>
<td></td>
</tr>
<tr>
<td>Pumice (O)</td>
<td></td>
</tr>
<tr>
<td>Obsidian (P)</td>
<td></td>
</tr>
<tr>
<td>Ash Tuff (R)</td>
<td></td>
</tr>
<tr>
<td>Vitric Tuff (T)</td>
<td></td>
</tr>
</tbody>
</table>
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 rocks.*
Goal: To introduce students to some of the tests that geologists use to determine the properties of minerals. 
Fits TN State standards: GLE 0707.7.1 Describe the physical properties of minerals

LESSON OUTLINE

I. Introduction
Discuss the difference between "rocks" and "minerals." Although some rocks contain just one mineral, most rocks are mixtures of two or more minerals. Give the class a Popcorn rock kit.

II. Learning the Tests That Help Distinguish Minerals
Organize the students into pairs. Explain that they will be learning how to do all the tests on hematite. Lead the students through each test using hematite. The five tests they will use are the streak test, hardness test, cleavage/luster test, and magnetism. Student pairs repeat the tests learned with hematite on their 2 minerals, record the results, and identify their minerals. Students also perform the acid test.

III. Other Properties of Minerals
Explain the property of fluorescence that some minerals exhibit. Also share some of the information about colored minerals.

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.

SAFETY NOTE Students must wear goggles when performing the Acid Test. If goggles are not available for all students, the VSVS volunteers must perform the acid test for the students. Be sure you wear the goggles!

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) Most rocks are made up of how many minerals?
2) What is a streak?
3) What is the Mohs scale?
4) What is the difference between cleavage and fractures?
5) What is luster?
6) How can you tell if a mineral is magnetic?
7) What carbonate mineral makes up limestone?

2. Use these fun facts during the lesson:
• Diamond is the hardest natural material.
• Gemstones like sapphires and rubies are minerals that are cut and polished.
• Minerals account for about 5% of the weight of a human body.
• The most abundant mineral in the body is calcium, and 99% of this is in the bones and teeth.

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 for students  Learning the Tests for Minerals
1 bag containing 16 pieces of muscovite,
1 bag containing 16 pieces of hematite
16 plastic bags containing 2 mineral samples (unknowns)
16 Mineral Investigation Kits containing: 1 hand lens, 1 piece of copper, 1 piece of iron, 1 piece of glass,
1 black streak plate, 1 white streak plate and 1 magnet
32 observation sheets

For Part II for VSVS Demonstrations:
1 bag of materials for VSVS members containing
3 types of calcite (yellow, blue and green)
1 piece of hematite
1 piece of muscovite
1 Mineral investigation kit (see below for contents)
1 bag (for demos) containing:
  a piece of aluminum foil
  a block of wood
  a piece of glass
  a sealed vial of ‘pearly’ beads

For Part F. Determination of the Unknown Minerals.
Properties of Minerals handouts

For Part G. Acid Test
For students: 16 plates, 16 dropper bottles of 0.5 M hydrochloric acid solution, 1 jar containing 16 pieces of marble, GOGGLES for all
For Demonstration: plus 4 large pieces of calcite

For Part III. Optional Other Properties: Color and Uses of Minerals
1 clear box with 12 samples of colored minerals, 16 Everyday Uses of Minerals handouts

I. Introduction – What are minerals?

Lesson Goals: Students understand that minerals make up rocks.

Why is the science in this lesson important?
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.

Write the following vocabulary words on the board: mineral, luster test, streak test, hardness test, Moh’s scale (moe’s), and cleavage test

Ask students, “What makes up rocks?”
• If students don’t mention minerals, tell students that all rocks are made up of minerals.
• If you look at any piece of rock closely, you will see that it is rarely completely smooth like plastic or metal. Instead it is made up of different grains or crystals.
• These crystals, which are sometimes minute and sometimes quite large, are called “minerals.”

Your Notes:
• Minerals are inorganic compounds that form naturally in the earth.

• A mineral has a definite composition, is a solid element or compound, and has a crystal shape.
  • There are more than 4,900 different kinds of minerals, but only 30 or so common ones.
  • Some rocks contain just one mineral. Most rocks are mixtures of two or more minerals.
  • The basic structure of a mineral is called a crystal.
    o A crystal is a solid in which the atoms are arranged in orderly, repeating patterns.
    o Crystals can come in different shapes and sizes. They can be rough, smooth, or in between. They can be very large, or very small. The size of the crystal depends on how fast the magma from which it became cooled.

Tell students that you are leaving a crystal growing kit. They can watch the crystals grow. Tell the teacher to follow the instructions included in the kit. Vinegar is supplied as well.

Ask students if they know where we get minerals.
  • “If it can’t be grown, it must be mined.”
  • Answers include from the earth, from mines, mining, from mountains. Tell students that we extract minerals from the earth through mining.

Tell students that minerals have properties that make them useful, including:
  • They can be melted and mixed to form new materials (e.g., steel)
  • They can be used as a source of metals like iron
  • They can be used by themselves (gemstones are one common example)

Write the name hematite (he-mah-tight) on the board and tell the students that this is one of the most important minerals mined. It is the most abundant and important ore of iron. It is used to make steel which, in turn, is used in everything from automobiles to flatware to the very machinery used to make almost everything else we use.
  • Tell students they will explore some of the uses for the other minerals at the end of the lesson

Ask students: How do scientists tell these minerals apart from each other?
  Scientists can identify minerals through several tests. Tell students they will learn how to do the tests using hematite, and then use the tests to identify an unknown mineral.

Your Notes:

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
Write the names of the “unknown” minerals (talc, rose quartz, smoky quartz, halite, galena, (guh-lee-nuh) magnetite, graphite, feldspar, calcite, gypsum) on the board, and tell the students that today, as geologists, they will investigate the 2 minerals assigned to each pair, record data about their properties and then be able to identify their minerals.

Note: Do not pass out acid dropper bottles and goggles until test E(b).
Do not pass out Properties of Minerals handout until after all tests have been done.

1. Distribute the following materials to each pair:
   1 Mineral Investigation Kit
   2 observation sheets
   1 set of 2 numbered minerals (unknowns) and 1 piece of hematite
2. VSVS members will lead the students through each test on the mineral hematite and have them record the results on their investigation sheets.

   When student groups are working independently, VSVS volunteers should circulate to monitor and help groups as needed.

3. After each test is done on hematite, the students will immediately do the same test on their 2 unknown minerals and record the results on their sheets.
4. After the pairs are finished with all the tests on their minerals, tell them to name their 2 minerals using the information on the Properties of Minerals Handout, which should only be handed out after all tests and observations are completed. Discuss the results and emphasize similarities and differences.

II. Learning the Tests for Minerals

   Learning Goals: Students will understand how to perform the various tests used by geologists (streak, hardness, breakage, luster, magnetism, acid).
   Students will understand how to use the results of tests to identify minerals.

A. Streak Test

Materials for VSVS members
1 hematite mineral
1 bag containing 3 types of Calcite (yellow, green and blue) and black and white streak plates

Explain the Streak Test.
- A "streak" is the color of a mineral when it is ground down to a powder.
- A streak test is a test that you do by pushing a mineral across a plate.
- This crushes up the mineral, allowing you to see a diagnostic color that a specific mineral has. The color of the mark left on the tile is the mineral’s streak.
- Show the students the three minerals (from the VSVS plastic bag) that are all calcite and emphasize their different colors. The different colors are from different impurities.
- Explain that a particular mineral can have several colors depending on impurities. While the color of a mineral may change, its powder and streak will usually stay the same.

Tell the students that the calcite minerals will have the same STREAK test result.
Show this by doing the streak test on the black streak plate. Keep the plate flat on the table like the image here.

Your Notes:

________________________________________________________________________

________________________________________________________________________
Testing the hematite. Tell the students to:

1. Gently stroke the edge of the hematite across the white streak plate.
   
   **Note:** Ask students to make only one streak per mineral since the tiles and minerals are needed for other classes.
2. Record the color that the streak produces. *Hematite has a red to brown streak*
3. Repeat the test on their unknown minerals using the black streak plate with light colored minerals and the white streak plate with the dark-colored minerals.
4. Record the results on their observation sheet.
   
   If no streak is visible on either plate, the students should record "not visible". (Note that “not visible” actually means that the mineral is harder than the streak plate). Make sure that the students have the following results, but do NOT tell the students the name of the mineral:

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Streak</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>red, brown</td>
</tr>
<tr>
<td>#2</td>
<td>white</td>
</tr>
<tr>
<td>#3</td>
<td>black</td>
</tr>
<tr>
<td>#4</td>
<td>white</td>
</tr>
<tr>
<td>#5</td>
<td>colorless, white</td>
</tr>
<tr>
<td>#6</td>
<td>black</td>
</tr>
<tr>
<td>#7</td>
<td>black, gray</td>
</tr>
<tr>
<td>#8</td>
<td>white</td>
</tr>
<tr>
<td>#9</td>
<td>white</td>
</tr>
<tr>
<td>#10</td>
<td>white</td>
</tr>
<tr>
<td>#11</td>
<td>colorless, white</td>
</tr>
</tbody>
</table>

B. Hardness Test

Another clue to a mineral’s identity is its hardness - that is, what will it or will it not scratch? Diamond is the hardest mineral to scratch, and has the highest rating (a 10). Talc (with a rating of 1) is one of the easiest to scratch.

A mineral’s hardness reflects how strong the mineral structure is.

**Explain Mohs Scale before performing this test.**

- Geologists have devised a set of common materials that are used to scratch a mineral to find where it lies on the hardness scale.
- Think about it – geologists often travel into outback areas and need to carry all their materials into the field with them. Carrying an electron microscope is not an option!
- The following everyday materials are sufficient for geologists to identify the hardness of minerals.

Your Notes:

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
These materials are:

**Hardness Testers (Everyday Equivalent Objects)**

1. no everyday equivalent
2. Fingernail
3. Copper coin or piece of copper
4. Iron nail/piece of iron
5. Glass
6. Penknife Blade
7. Steel File
8. Sandpaper
9. no everyday equivalent
10. no everyday equivalent

- Tell students we will be using just four of the everyday equivalents (“testers”) in this lesson. Since several classes will be using the minerals, the students will **scratch the testers** with the mineral.

**NOTE:** Ensure that all testers, especially the glass plate, are flat on the table surface while scratching (like the image). If held aloft, the glass will snap in half.

**Testing the hardness of hematite.**

Tell the students to:

1. Determine the Mohs hardness of **hematite** by finding the HARDEST tester that the mineral will scratch.
   
   Once a mineral scratches a tester, **do not** continue to try to scratch softer testers (because it will!). Remember these testers and minerals will be used by other classes.

2. Find the hardness of **hematite** by scratching the **testers** with the hematite, in the following order (from hardest to softest):
   
   1. piece of glass (hardest)
   2. piece of iron
   3. piece of copper
   4. fingernail (softest)

3. Circle the first tester the hematite scratches, along with the Moh’s number that is with it.
   
   If the hematite scratches the glass, its hardness is greater than 5 (>5).
   
   If the hematite scratches the iron, its hardness is 4-5.
   
   If the hematite scratches the copper, its hardness is 3-4.
   
   If the hematite scratches your fingernail, its hardness is 2-3.
   
   If the hematite does not scratch your fingernail, its hardness is 1-2.

   Make sure that the students have the following results for Hematite = 4-5 or >5

4. Repeat the test on the 2 unknown minerals and record the results.

**Hardness Test Results.**

Make sure that the students have the following results (Some students may get slightly different results. The following ranges are acceptable. Use the number on the mineral to determine if the students have the correct results.):

---

Your Notes:

________________________________________________________________________

________________________________________________________________________
C. Cleavage and Fracture Test (Breakage Test)

Materials:
1 bag containing 16 pieces of muscovite

Minerals can break in different ways, depending on how strong the bonds are between the atoms in the mineral. They will break along the planes that are the weakest. They can break by either cleaving or fracturing.

NOTE: Do not break the minerals!! Cleavages will already be apparent as smooth surfaces.

Tell the students that if the mineral cleaves, they will see flat surfaces.

Some minerals can break into sheets (cleavage in one direction).

Distribute the samples of muscovite around the class and point out the sheets.

Tell them that the pioneers used muscovite for windows.

Others minerals can cleave in several directions (diamonds cleave in 4 directions).

If a mineral fractures, it breaks unevenly along curved or irregular surfaces.

Testing the hematite for cleavage/fractures,

1. Have the students look at their hematite tell them that it has no cleavage.

2. Help them determine if their unknown minerals cleave into planes or fracture. The answers are given on their Instruction sheet. Point out the cleavage planes or fracture pattern.
Cleavage And Fracture Test (Breakage) Results.
Tell the students to look at their minerals and make sure they circle the correct answer on their observation sheet.

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Cleavage/Fracture</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1 Hematite</td>
<td>no cleavage, fractures</td>
</tr>
<tr>
<td>#2</td>
<td>cleaves - 1 direction, look for layers</td>
</tr>
<tr>
<td>#3</td>
<td>no cleavage, fractures</td>
</tr>
<tr>
<td>#4</td>
<td>cleaves - 3 directions</td>
</tr>
<tr>
<td>#5</td>
<td>no cleavage, fractures</td>
</tr>
<tr>
<td>#6</td>
<td>cleaves - cubic</td>
</tr>
<tr>
<td>#7</td>
<td>cleaves - (scales)</td>
</tr>
<tr>
<td>#8</td>
<td>cleaves</td>
</tr>
<tr>
<td>#9</td>
<td>cleaves - 2 planes</td>
</tr>
<tr>
<td>#10</td>
<td>cleaves - cubic</td>
</tr>
<tr>
<td>#11</td>
<td>no cleavage, fractures</td>
</tr>
</tbody>
</table>

D. Luster (Shininess) Test
Materials:
1 bag containing aluminum foil, wood, glass, and a container with a pearly substance.
- The way a mineral reflects light is called luster.
- Show the students the aluminum foil, the glass and the wooden block.
- Explain the terms metallic luster and nonmetallic luster by showing the following examples:
  - The aluminum foil has a metallic luster – it reflects light well. It is shiny and looks like a metal. Ask students for other examples that illustrate metallic luster (stainless steel pots, etc).
  - If the mineral does not look like a metal, it is classified as having a non-metallic luster.
    - These minerals can be further classified as being:
      - dull – show the students the wood
      - glassy – show the students the glass
      - pearly – show the students the vial of pearly beads

Testing the hematite for luster:
1. Tell the students to examine their hematite to determine its luster (it has a non-metallic luster).
2. Students may need to hold the mineral up to a light or look through the magnifying glass, to see “specks” of metallic luster.
3. Have them record the result on their investigation sheets.
4. Then have the students do the same test on the other minerals and record the results.

Make sure the students have the following results (but do not tell them the name of the minerals):

Your Notes:
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
<table>
<thead>
<tr>
<th>Mineral</th>
<th>Luster</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>non-metallic – dull</td>
</tr>
<tr>
<td>#2</td>
<td>non-metallic – pearly</td>
</tr>
<tr>
<td>#3</td>
<td>metallic</td>
</tr>
<tr>
<td>#4</td>
<td>non-metallic – glassy or pearly</td>
</tr>
<tr>
<td>#5</td>
<td>non-metallic – glassy</td>
</tr>
<tr>
<td>#6</td>
<td>metallic</td>
</tr>
<tr>
<td>#7</td>
<td>metallic</td>
</tr>
<tr>
<td>#8</td>
<td>non-metallic – glassy</td>
</tr>
<tr>
<td>#9</td>
<td>non-metallic – dull or pearly</td>
</tr>
<tr>
<td>#10</td>
<td>non-metallic – glassy</td>
</tr>
<tr>
<td>#11</td>
<td>non-metallic – glassy</td>
</tr>
</tbody>
</table>

**E. Magnetism Test**

Explain that some minerals are magnetic. These minerals will be attracted to a magnet. If the mineral is attracted to a magnet, the mineral is magnetic. If there is an attraction, the students circle yes; if not, circle no.

1. Have the students do **this test on hematite** by touching the magnet to the mineral. It is not magnetic.
2. Repeat on their unknown minerals. **# 3 is the only mineral that attracts a magnet**
3. Take out your sample #3, **DO NOT** say its name, and show the students that some minerals do actually attract a magnet (only a few students will have this sample).

**F. Determination of the Unknown Minerals.**

Pass out the **Properties of Minerals Handout** and tell students to use it to help them determine the names of their minerals. Circulate around the room while the students are working and help them as needed.

**G. Acid Test**

Explain the acid test:

- There is an important group of minerals called "carbonates" which contain carbon and oxygen. Most tend to be fairly soft and whitish in appearance. Acid makes carbonates fizz and bubble. Geologists use dilute hydrochloric acid when they perform an acid test.

**Demonstration**

- Show students the acid test on Calcite.
- Place the calcite pieces on plates and take them to groups to show them what happens when drops of acid are put onto the mineral. Use magnifiers if needed.

**Student experiment:**

**CAUTION:** This acid must be used with care. The mixture contains only 0.5 M acid, but students should not be allowed to play around or squirt this on anything but the mineral. **If the class tends to be unruly or if enough goggles are not available for the students, the VSVS volunteers should take the acid to the groups and put it on the marble pieces for them. Then the students can observe and record their observations.**

Your Notes:
Before any student touches the acid dropper bottle, make sure ALL students are wearing their goggles and continue to do so until the acid is removed from their tables!!!
Pass out the Goggles, acid, plates, and piece of marble. Explain to the students that marble is a type of rock, NOT a mineral. Explain that they will be testing the marble to see if it reacts with acid.

Tell the students to:
1. Put the marble on their plate.
2. Use the dropper bottle to carefully put a few drops of acid on the marble.
3. Use the hand lens to examine the marble to see if there is any sign of a fizzing or bubbling reaction. Students should see a bubbling reaction. Walk around the room to make sure everyone sees this reaction. Have them record their results on their observation sheet.
4. Tell them to use their Properties of Minerals Handout and see if they can determine what mineral is in the rock marble. The answer is calcite.
5. Have them record their answer on their observation sheet.

Ask the students:
Do you know of any other rock, which is common to Tennessee, that “fizzes” when acid is added? limestone
What mineral do you suppose is in limestone? calcite

III. Optional
Everyday Uses of Minerals
Tell students to look at the Everyday Uses of Minerals Handout. As each mineral is discussed, have a VSVS member hold up the mineral from the VSVS mineral box).
Other Properties: Color (If there is enough time)
A team member can take the box of sample colored minerals around to each group while some of the information about colored minerals is shared from the next page.

Lesson written by Pat Tellinghuisen, Coordinator of VSVS, Vanderbilt University
Dr. Melvin Joesten, Chemistry Department, Vanderbilt University
Courtney Luckabaugh, VSVS Lab Assistant, Undergraduate, Vanderbilt University
We gratefully acknowledge the assistance of Professors Molly and Calvin Miller, Vanderbilt University.
Mineral Color Kit Information Sheet

How Minerals Are Colored

Share some of this information with the student groups as you show them the 12 mineral samples in the kit.

BACKGROUND INFORMATION ONLY: When light strikes the surface of a mineral, some wavelengths will be absorbed and some will be reflected. The color we see results from the combination of reflected wavelengths of light. Minerals that are colorless or white reflect the total spectrum of light.

For some minerals, color is a fundamental characteristic of its chemical composition. These minerals are termed idiochromatic, meaning that they will always display the same color. (Minerals 1, 2, 3 and 9.)

Certain metallic minerals with similar compositions but differing states of oxidation will exhibit different colors. (Minerals 5, 6, 7 and 10)

Many minerals contain trace elements in their composition which control their color. These trace elements are called chromophores. (Minerals 4 and 8)

Some minerals will display a range of colors due to the mixing of impurities. These impurities may be combinations of minerals or organic compounds.

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Color</th>
<th>Formula</th>
<th>Reason for color</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Sulfur</td>
<td>yellow</td>
<td>S</td>
<td>chemical composition</td>
</tr>
<tr>
<td>2. Pyrite</td>
<td>brass-yellow</td>
<td>FeS₂</td>
<td>chemical composition</td>
</tr>
<tr>
<td>3. Fluorite</td>
<td>pink</td>
<td>CaF₂</td>
<td>chemical composition</td>
</tr>
<tr>
<td>4. Beryl</td>
<td>green</td>
<td>Be₃Al₂(Si₆O₁₈)</td>
<td>contain trace elements</td>
</tr>
<tr>
<td>5. Magnetite</td>
<td>black</td>
<td>Fe₃O₄</td>
<td>oxidation state</td>
</tr>
<tr>
<td>6. Olivine</td>
<td>green</td>
<td>(Fe, Mg)₂SiO₄</td>
<td>chemical composition</td>
</tr>
<tr>
<td>7. Hematite</td>
<td>red</td>
<td>Fe₂O₃</td>
<td>oxidation state</td>
</tr>
<tr>
<td>8. Quartz</td>
<td>pink</td>
<td>SiO₂</td>
<td>contain trace elements</td>
</tr>
<tr>
<td>var. Rose (Titanium)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Malachite</td>
<td>green</td>
<td>Cu₂CO₃(OH)₂</td>
<td>chemical composition</td>
</tr>
<tr>
<td>10. Limonite</td>
<td>yellow-brown</td>
<td>(Fe₂O₃·H₂O)</td>
<td>chemical composition</td>
</tr>
<tr>
<td>11. Gypsum var. Selenite colorless</td>
<td></td>
<td>CaSO₄·H₂O</td>
<td>chemical composition</td>
</tr>
<tr>
<td>12. Halite</td>
<td>pink</td>
<td>NaCl</td>
<td>mixing of impurities</td>
</tr>
</tbody>
</table>
Name__________________________________________

**Minerals Observation Sheet**

<table>
<thead>
<tr>
<th>Sample #</th>
<th>1</th>
</tr>
</thead>
</table>

**Streak**
*What color is the streak when the mineral is rubbed on the tile?*

<table>
<thead>
<tr>
<th>Glass &gt;5</th>
<th>Glass &gt;5</th>
<th>Glass &gt;5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron Nail 4-5</td>
<td>Iron Nail 4-5</td>
<td>Iron Nail 4-5</td>
</tr>
<tr>
<td>Copper 3-4</td>
<td>Copper 3-4</td>
<td>Copper 3-4</td>
</tr>
<tr>
<td>Fingernail 2-3</td>
<td>Fingernail 2-3</td>
<td>Fingernail 2-3</td>
</tr>
<tr>
<td>Nothing 1-2</td>
<td>Nothing 1-2</td>
<td>Nothing 1-2</td>
</tr>
</tbody>
</table>

**Hardness**
*Start by trying to scratch the top item and stop when an item is scratched by the mineral. Circle the first item that is scratched and the number from the Mohs’ scale that goes with it.*

<table>
<thead>
<tr>
<th>Glass &gt;5</th>
<th>Glass &gt;5</th>
<th>Glass &gt;5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron Nail 4-5</td>
<td>Iron Nail 4-5</td>
<td>Iron Nail 4-5</td>
</tr>
<tr>
<td>Copper 3-4</td>
<td>Copper 3-4</td>
<td>Copper 3-4</td>
</tr>
<tr>
<td>Fingernail 2-3</td>
<td>Fingernail 2-3</td>
<td>Fingernail 2-3</td>
</tr>
<tr>
<td>Nothing 1-2</td>
<td>Nothing 1-2</td>
<td>Nothing 1-2</td>
</tr>
</tbody>
</table>

**Cleavage or Fracture?**
*Breakage Patterns*
*Does it appear to break/cleave in specific directions/shapes (breaks off in sheets, cubes, etc) or does it fracture/just break randomly/roughly?*

<table>
<thead>
<tr>
<th>Cleavage</th>
<th>Cleavage</th>
<th>Cleavage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shape/# of directions:</td>
<td>Shape/# of directions:</td>
<td>Shape/# of directions:</td>
</tr>
<tr>
<td>OR</td>
<td>OR</td>
<td>OR</td>
</tr>
<tr>
<td>Fracture</td>
<td>Fracture</td>
<td>Fracture</td>
</tr>
</tbody>
</table>

**Luster**
*Is it metallic or nonmetallic? If nonmetallic, is it dull, pearly or glassy? Circle answers.*

<table>
<thead>
<tr>
<th>Metallic</th>
<th>Nonmetallic</th>
<th>Metallic</th>
<th>Nonmetallic</th>
<th>Metallic</th>
<th>Nonmetallic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dull</td>
<td>Pearly</td>
<td>Glassy</td>
<td>Dull</td>
<td>Pearly</td>
<td>Glassy</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Magnetic?**
*Is it attracted to a magnet? Circle.*

<table>
<thead>
<tr>
<th>Yes</th>
<th>Yes</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>OR</td>
<td>OR</td>
<td>OR</td>
</tr>
<tr>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

**Mineral Name**
*Hematite*

1. What happened when you put drops of acid on the marble? ______________________
2. What mineral is in marble? ______________________
3. What other rock commonly found in Tennessee reacts like marble with acid? ______________________
4. What mineral is in this rock? ______________________
# Properties of Minerals

<table>
<thead>
<tr>
<th>Streak</th>
<th>Red, Brown</th>
<th>White</th>
<th>Colorless/White</th>
<th>Black</th>
<th>White</th>
<th>White</th>
<th>Colorless/White</th>
<th>Black, Gray</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hardness</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glass &gt;5</td>
<td>Fingernail</td>
<td>Glass &gt;5</td>
<td>None 1-2</td>
<td>None</td>
<td>None 1-2</td>
<td>None</td>
<td>Glass &gt;5</td>
<td>None</td>
</tr>
<tr>
<td>OR Iron 4-5</td>
<td>OR Iron 4-5</td>
<td>OR Iron 4-5</td>
<td>Iron 4-5</td>
<td>Iron 4-5</td>
<td>Iron 4-5</td>
<td>Iron 4-5</td>
<td>Iron 4-5</td>
<td>Iron 4-5</td>
</tr>
<tr>
<td><strong>Cleave or Fracture? Breakage Patterns</strong></td>
<td>Fracture</td>
<td>Cleavage Cubic</td>
<td>Fracture</td>
<td>Fracture</td>
<td>Cleavage</td>
<td>Cleavage</td>
<td>Fracture</td>
<td>Cleavage (Scales) [note the lines going across the surface]</td>
</tr>
<tr>
<td>Luster</td>
<td>Nonmetallic</td>
<td>Nonmetallic</td>
<td>Nonmetallic</td>
<td>Metallic</td>
<td>Nonmetallic</td>
<td>Nonmetallic</td>
<td>Metallic</td>
<td>Nonmetallic</td>
</tr>
<tr>
<td>Dull</td>
<td>Glassy</td>
<td>Glassy</td>
<td>Metallic</td>
<td>Glassy</td>
<td>Pearly</td>
<td>Glassy</td>
<td>Metallic</td>
<td></td>
</tr>
<tr>
<td>Attracted to Magnet?</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Reacts with Acid?</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Mineral Name</td>
<td>Hematite</td>
<td>Halite</td>
<td>Rose Quartz</td>
<td>Magnetite</td>
<td>Gypsum</td>
<td>Talc</td>
<td>Smoky Quartz</td>
<td>Graphite</td>
</tr>
<tr>
<td>Sample Number</td>
<td>1</td>
<td>10</td>
<td>5</td>
<td>3</td>
<td>8</td>
<td>2</td>
<td>11</td>
<td>7</td>
</tr>
<tr>
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<td>---</td>
<td>---</td>
<td>---</td>
<td>----</td>
<td>---</td>
</tr>
<tr>
<td><strong>Streak</strong></td>
<td>Red, Brown</td>
<td>White</td>
<td>Colorless/White</td>
<td>Black</td>
<td>White</td>
<td>White</td>
<td>Colorless/White</td>
<td>Black, Gray</td>
</tr>
<tr>
<td><strong>Hardness</strong></td>
<td>Glass &gt;5 OR Iron 4-5</td>
<td>Fingernail 2-3 OR None 1-2</td>
<td>Glass &gt;5 OR Iron 4-5</td>
<td>None 1-2</td>
<td>None 1-2</td>
<td>Glass &gt;5 OR Iron 4-5</td>
<td>None 1-2</td>
<td></td>
</tr>
<tr>
<td><strong>Cleave or Fracture? Breakage Patterns</strong></td>
<td>Fracture</td>
<td>Cleavage Cubic</td>
<td>Fracture</td>
<td>Fracture</td>
<td>Cleavage</td>
<td>Cleavage one direction – look for layers</td>
<td>Fracture</td>
<td>Cleavage (Scales) [note the lines going across the surface]</td>
</tr>
<tr>
<td><strong>Luster</strong></td>
<td>Nonmetallic Dull</td>
<td>Nonmetallic Glassy</td>
<td>Nonmetallic Glassy</td>
<td>Metallic</td>
<td>Nonmetallic Glassy</td>
<td>Nonmetallic Pearly</td>
<td>Nonmetallic Glassy</td>
<td>Metallic</td>
</tr>
<tr>
<td><strong>Attracted to Magnet?</strong></td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td><strong>Reacts with Acid?</strong></td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td><strong>Mineral Name</strong></td>
<td>Hematite</td>
<td>Halite</td>
<td>Rose Quartz</td>
<td>Magnetite</td>
<td>Gypsum</td>
<td>Talc</td>
<td>Smoky Quartz</td>
<td>Graphite</td>
</tr>
</tbody>
</table>

1. What happened when you put drops of acid on the marble? It **fizzes**
2. What mineral is in marble? **Calcite**
3. What other rock commonly found in Tennessee reacts like marble with acid? **Limestone**
4. What mineral is in this rock? **Calcite**
Goal: To investigate properties of waves by studying reflection, diffraction, and refraction of light.

TN State standards:
- GLE 0707.11.5 Compare and contrast the basic parts of a wave
- GLE 0707.11.6 Investigate the types and fundamental properties of waves
- PS CLE 3202.2.1 Investigate the properties and behaviors of mechanical and electromagnetic waves.

**VSVSer LESSON OUTLINE:**

I. Introduction

- Students discuss the properties of waves.

II. Types of Waves

III. Wave Behavior

A. Reflection

   a. Using a Mirror - Students use a laser pointer, a mirror, and a finger to trace the path of the reflected laser beam. Students observe that the angle of reflection is the same as the angle of incidence.

   b. Demonstration: Using a Light Pipe - A VSVS member shines a red laser through a light pipe to demonstrate total internal reflection.

B. Refraction

- Refraction will be demonstrated using a jar of water and a straw.

C. Diffraction

   a. Diffraction Gratings - Students hold up what looks like a blank slide and look at room lights or outdoor light through a window and see separation of white light into several rainbows.

   b. CDs - Students hold the CD in a way that produces “rainbow” patterns. CDs have many parallel grooves, so the CD acts like a diffraction grating.

D. The Appearing Coin

- Students will learn a “magic” trick using the concept of refraction.

**LOOK AT THE VIDEO BEFORE YOU GO OUT TO YOUR CLASSROOM**

https://studentorgs.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.

   1) State the definition of a wave.
   2) Which four behaviors do all waves exhibit?
   3) State the law of reflection applicable to all waves.
   4) What is the significance of the critical angle of a substance?
   5) What are the two conditions for refraction of a wave to occur?
   6) Why does a CD appear to have a rainbow pattern in white light?

2. Use these fun facts during the lesson

   - There are lots of waves surrounding us, such as sound waves, light waves, and water waves.
   - Electromagnetic Spectrum: This is the name given to all the different kinds of waves that can move through a vacuum (empty space). They include radio waves, microwaves, infra-red radiation, visible light, ultra-violet (UV), x-rays, and gamma rays. The only ones that we can see make up visible light.
However, we still use many of the invisible ones in everyday life, such as microwaves for heating up food and x-rays to see bones.

- **Sound Waves:** The loud noise created by cracking a whip occurs because the tip is moving faster than the speed of a sound wave. Similarly, when an aircraft moves faster than the speed of sound, a sonic boom is heard!
- **Lightning and Thunder:** Why is it that thunder is always heard after the lightening is seen? The speed of a light wave, which is 186,000 miles per second, is much faster than the speed of a sound wave which is 770 miles per hour.
- **Earthquakes:** These are caused by waves that transport the energy stored in rocks deep inside the Earth to the Earth’s surface. They are called seismic shock waves.

**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. Types of Waves**
String wave machine and Slinky
32 Observation sheets
16 Instruction sheets (in page protectors)

**For Part III: Wave Behavior**
**For IIIA. Reflection**
a. **Using a Mirror** 16 bags containing: 1 mirror mounted on a block of wood, 1 red laser pointer
b. **Demonstration: Using a Light Pipe**
1 acrylic light pipe and laser pointer

**For IIIB. Refraction**
8 4oz jars containing water and a straw

**For IIIC. Diffraction**
32 CDs, 32 diffraction gratings

**For IIID. Optional: The Appearing Coin**
8 cups with a penny taped in the center, 8 bottles of water

**I. Introduction**

| Learning Goals: By the end of the lesson, students should know the following: |
| What is a wave? What forms can waves take? |

**Why is the science in this lesson important?**
Light and other electromagnetic radiation are waves, and scientists are able to manipulate classical properties of waves, such as refraction or reflection. Solar thermal farms in the Mojave Desert use 170,000 giant mirrors to reflect sunlight onto water towers to heat the water over 1000 degrees Fahrenheit. The water then turns into steam and turns turbines, providing a renewable source of energy to reduce our carbon footprint.

Write the following vocabulary words on the board: **wave, reflection, diffraction, refraction, laser**
*Ask students to tell what they know about waves.*
These points may come up in the discussion or you may choose to add them to the discussion. Remember to keep this discussion short.
“A wave is a disturbance that transfers energy from one place to another without transferring "matter". (From Glencoe text.)

- There are 2 types of waves – transverse and compressional.
- All waves have properties that can be measured – amplitude, wavelength, and frequency.
- All waves exhibit the same behavior – reflection, refraction, diffraction, and interference.

II. Types of Waves

Learning Goals: Students will learn that there are 2 types of waves (transverse and compressional). Students will be able to identify the parts of a wave (amplitude, frequency, wavelength, crest, trough).

Materials: String wave machine, Slinky
Two volunteers need to perform this demonstration.

- Hold the slinky so that there is no slack between the two ends.
- For the compressional wave, have one volunteer pull back on the slinky (as if cocking a spring) and release it. This should result in a pulse traveling down the length of the slinky.
  - Tell students that this is an example of a longitudinal wave. Sound waves are compressional (longitudinal) waves.
- Have one volunteer slowly move the slinky up and down (the other volunteer should hold it steady).
  - This is an example of a transverse wave. Light waves are transverse waves.

Compressional wave

Transverse wave

www.physicsclassroom.com/Class/waves/U10L1a.html

Turn the wave machine on and adjust it so that it has 2 standing waves (see training presentation).

Point out the crest, trough, amplitude and wavelength

Draw the wave diagrams (below) on the board.
Tell the students that they will be using lasers to study some properties of light waves, and that there are several rules that must be followed:

Be very careful with the laser pointer.
Never aim it at anyone.
When turning it on, always have it pointed away from your eyes and from other persons. Eye damage can occur with direct eye exposure to some laser beams.

For the transverse wave, the wavelength is A-E, or D-G etc

For a compressional wave the compressions and rarefactions regions are shown. Point out that A-C or B-D represents a wavelength for the longitudinal wave.

III. Wave Behavior

**Learning Goals:** Students will learn how waves behave by studying reflection, refraction and diffraction. Students will know what “laser” stands for and how a laser is used safely.

A. Reflection

Tell students they are going to investigate how waves behave, by studying light waves. The term “laser” is an acronym for Light Amplification by Stimulated Emission of Radiation. Lasers emit a single wavelength of light; the wavelength of the red laser pointer light is 670 nanometers.

**Safety Note:** Tell the students that they will be using lasers to study some properties of light waves, and that there are several rules that must be followed:

Be very careful with the laser pointer.
Never aim it at anyone.
When turning it on, always have it pointed away from your eyes and from other persons. Eye damage can occur with direct eye exposure to some laser beams.

a. Using a Mirror - Divide the class into pairs.

**Materials – each pair needs:**
- 2 Observation sheets
- 1 Instruction sheet
- 1 Mirror mounted on a wooden block
- 1 laser pointer

Ask students what happens to light when it strikes a surface.

- When light strikes an object, it is either transmitted (allowed to pass through the object), or reflected (bounced back to your eyes so that you can see the object) or absorbed.
- When light hits a smooth surface, such as a mirror, regular reflection occurs. Ask students what we call the image that we see in the mirror. A reflection.
- Tell students that they are going to experiment with reflecting light in a mirror.
Tell the students to:
1. Place the block of wood with the mirror on the marked line on the observation sheet.
2. Designate one student to hold the laser pointer. Remind the students to NEVER look directly into a laser beam.
3. Shine the laser along the solid 45° line and toward the “X”.
4. Angle the laser so that you can see it travelling along the 45° incident line and out along its reflected beam.
5. “Trace” the laser beam with a finger along the 45° line in towards the mirror.
6. Now tell the students to trace the reflected beam with a finger and to note which line the finger moves along. (It should be close to the dotted 45° line.)

7. Tell the students that the light from the laser to the mirror is called the incident ray and the light from the mirror is the reflected ray.
8. Explain that when light goes in at an angle on one side (left or right), it comes out at the same angle on the other side. (It is helpful to some students if you draw this on the board or relate it to a billiard table.)

**Note:** The concept the students should learn is that light can bounce or reflect. Light goes in at one angle and comes out on the opposite side at an equal angle.

9. Allow the students to try other angles (moving the ruler and laser) to see what happens. Remind students to aim for the “X” in the center.
10. After a brief time of experimentation with other angles, ask the students what they can conclude about the reflection of light.
    o Light can be reflected by using a mirror.
    o When you shine a light straight into a mirror, it comes straight back.
    o When you shine a light into a mirror at an angle, it will come out at an equal angle on the opposite side of the mirror.
    o Incoming light is reflected at the same angle as the outgoing light.

10. Ask students how other waves show reflective behavior.
    Sound waves can echo, water waves bounce back from a barrier.

**b. Demonstration: Using a Light Pipe.**

**Materials:**
1 acrylic light pipe
1 laser pointer

Show the students the acrylic light pipe.
- Hold the light pipe so that the long part is vertical and the small horizontal part is pointing towards the class (but not directly at any person’s eyes).
• Shine the red laser beam up towards the ceiling and have the students notice the red color on the ceiling.
• Turn off the classroom lights, and ask students what they think they will see when the red laser is shone through the long end of the pipe. If the room is not dark, take the light pipe to each group.
• Shine the laser through the long horizontal end of the pipe.
• Show students that the red light can be seen at the other end, but that no light escapes along the pipe.
• If the room is dark enough, the red light can be seen traveling around the tube.

Explaination: When the angle of incidence is high enough (above a critical angle characteristic of the substance; 42° for glass), the incident light is totally reflected inside the medium. Because of total internal reflection, light can be "piped" from one location to another in glass, plastic rods, or other fiber optic material. On entering the "light pipe" at an angle greater than the critical angle of pipe material, the light undergoes repeated internal reflections and follows the contour of the pipe.

B. Refraction

Materials -  8 oz jars with straw and water

Water Refracts Light
1. Distribute the 8 jars containing water and a straw to students – 1 per 3 or 4 students.
2. Tell the students to rotate the jar while looking at the straw, which should be lying at an angle in the jar. Ask them what they observe. The straw will appear to be bent at the point where it emerges from the water.
3. Tell the students to unscrew the lid and to hold the straw vertically in the center of the jar so that half is in the water and half is out of the water. Look at the straw “straight on” at the center point, and then slowly move it to the side of the glass (do not move your head with the straw). Ask them what they observe.
4. Tell students to hold their observation sheet behind the jar and shine the laser through the water in the jar. Note where the red beam is on the paper.
5. Tell students to move the laser up so that the beam now shines through the air in the jar. Note where the beam moves to on the observation sheet.

Explanation:
- The bending of light - refraction - occurs when light waves pass from one medium (or substance) to another.
- The speed of a wave depends on the substance that it is traveling through. Since light is a wave, its speed changes when it changes medium. In this example, the speed of light is slower in water than in air.
- As the wave slows down, it also changes its direction. So the light wave “bends” as it enters the water.
- Refraction only occurs when light waves pass into a different medium, at an angle.
- The straw did not appear to be “broken” when viewed in the center of the jar. (When you look at it “straight-on”.)

Your Notes:
▪ The straw becomes more “broken” as it moves across the jar. (When you look at it from different angles.)


Important. Collect all laser pointers and count them to make sure you have them all. **Do not continue with the lesson until you have placed the laser pointers in the VSVS box.** Also, make sure the laser pointers are not left on.

### C. Diffraction

**Materials:**
- 32 CDs
- 32 diffraction gratings

Ask students if they know what diffraction is.
- All waves can be bent when they move around a barrier or through an opening, this is called **diffraction**.
- For light to be diffracted, it must pass through a slit that is very narrow.

**a. Looking Through a Diffraction Grating**

A VVS volunteer should show students how to hold the diffraction grating.
- Hold the slide by the cardboard only.
- Do not touch the clear film in the cardboard holder.
- Hold the diffraction grating close to (but not touching) the eye, and look at any lights or windows in the room.
- Several rainbows should appear.

Hand out a diffraction grating and CD to each student.

**CAUTION:** Do not look directly at the sun with a diffraction grating.

**Explanation:**
- Diffraction grating slides consist of many equally spaced parallel grooves -- typically about 1500 lines per centimeter.
- Each space between two grooves acts as a slit through which light can pass.
- The light bends around the edges of the grooves.
- When illuminated with white light, the diffraction grating has the same effect as a prism in that it separates white light into a spectrum of colors.
- The order of the colors, however, is opposite from that seen in a spectrum made by a prism. A diffraction grating will also split a laser beam.

**b. CD**

Tell the students to pick up the CD and notice the “rainbow” pattern from the room lights.
- CDs have many parallel grooves so the CD acts as a diffraction grating.
- The different colors in white light are bent different amounts, so a full spectrum of color can be seen when light is shone onto a CD.
- All wavelengths are diffracted at different rates, so diffracted visible light is split into a rainbow of colors.

Your Notes:

_____________________________________________________________________________________________

_____________________________________________________________________________________________
Sound waves diffract around buildings – you can hear sounds that are made around “corners”. Light waves cannot diffract around buildings – you cannot see around corners if a building is in the way.

**D. The Appearing Coin**

**Materials:**
- 8 cups with a penny taped in the center
- 8 bottles of water

Tell students that the next activity involves the property of refraction and may be used as a magic trick to try on their family.

Have students in each group do the following:
1. Place the Styrofoam cup with the penny on the desk.
2. Select one student in each group to pour the water.
3. Have the students in the group stand so that they can easily see the coin.
4. Now have the students back up slowly and stop when the coin has just disappeared from sight. (Tell the students that they may not stop at the same point as other students because they are different heights and have different lines of vision. They should stop just as soon as the coin disappears from sight and should not go back too far.)
5. Tell the designated student to slowly pour water in the cup. The other students should raise their hands as soon as they can see the coin again.
6. Continue to pour the water into the cup until all the students raise their hands. (If they cannot see the coin, they went back too far.)

**Explanation:** Refraction causes this effect. When water is added, the light is bent so that the coin becomes visible. This experiment shows that light is bent as it travels at an angle through one medium (water) into another (air). As light rays from the coin cross the water/air boundary, they speed up and bend. Our brains are programmed to assume that light rays travel straight from an object to our eyes. Therefore we see the coin straight in front of our eyes.

**IV. Review**

Review the properties of waves that have been discussed today, and ask students if they can tell you some examples seen or heard in everyday life.
1. Reflection – Images can be seen in dark sunglasses. Echoes are an example of reflected sound waves. Some animals depend on echoes to locate food.
2. Refraction – Rainbows are created when light is refracted when it travels through water droplets or prisms.
3. Diffraction - Sound can be heard in different rooms because its waves can be diffracted around solid objects.

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Emily Culver, Former President of VSVS, Vanderbilt University
John Kidd, NSF Undergraduate Teaching Fellow, Vanderbilt University
Frank Merendino, Undergraduate Teaching Fellow, Vanderbilt University

Your Notes:
1. Reflection

<table>
<thead>
<tr>
<th>Incident Angle</th>
<th>Angle of Reflection</th>
</tr>
</thead>
<tbody>
<tr>
<td>45°</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. Refraction

Draw what the straw looks like when it has been moved to the side of the jar.

Hold this observation sheet behind the jar.

Mark the position of the red dot from the laser when it is shone thru air and then water, along dashed line and then the dotted line.

Explain

3. Diffraction

What colors do you see through the diffraction grating?

From the CD?