7th Grade

Spring 2019 Lesson Plans

Vanderbilt Student Volunteers for Science

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

VOLUNTEER INFORMATION

Team Member Contact Information

Name:____ Phone Number:________________________

Name:____ Phone Number:________________________

Name:____ Phone Number:________________________

Name:____ Phone Number:________________________

Name:____ Phone Number:________________________

Teacher/School Contact Information

School Name: ___________________________________ Time in Classroom: ____________________

Teacher's Name: __________________________________ Phone Number: ______________________

VSVS INFORMATION

VSVS Educational Coordinator:

Paige Ellenberger 615-343-4379
paige.ellenberger@vanderbilt.edu **VSVS Office:** Stevenson 5234

Co-Presidents:	Eric Zhang	eric.zhang@vanderbilt.edu
	Vineet Desai	vineet.desai@vanderbilt.edu
Secretaries:	Gabriela Gallego	gabriela.l.gallego@vanderbilt.edu
	Emily Chuang	emily.a.chuang@vanderbilt.edu

Vanderbilt Protection of Minors Policy: As required by the Protection of Minors Policy, VSVS will keep track of the attendance – who goes out when and where.
https://www4.vanderbilt.edu/riskmanagement/Policy_FINAL%20-%20risk%20management%20v2.pdf

Before You Go:

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

Picking up the Kit:

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

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

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

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

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

April						
SUN	MON	TUES	WED	THU	FRI	SAT
31	1 Teams go out (Lesson 4)	2 Teams go out (Lesson 4)	3 Teams go out (Lesson 4)	4 Teams go out (Lesson 4)	5 Teams go out (Lesson 4)	6
7	8 Make-up week	9 Make-up week	10 Make-up week	11 Make-up week	12 Make-up week	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

CLASSROOM ETIQUETTE

Follow Metro Schools' Dress Code!

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

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

COLLEGE Q&A SESSION

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

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

- Emphasize the hardworking attitude.

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

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

DIRECTIONS TO SCHOOLS

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

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

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

The parking lot on the left to the Johnston Ave.

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

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

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

Going down Ramsey Street, Meigs is on the left.

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

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

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

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

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

MARGARET ALLEN MIDDLE SCHOOL: 500 SPENCE LN **615- 291- 6385**

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

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

Ultraviolet Light

Mini Lesson for Spring 2019

Goal: To study the properties of ultraviolet light (UV light). To test the ability of various substances to protect skin against UV light.
Fits TN standards : 7.ESS3.2

VSVSer	Lesson Outline:
_______	**I. Introduction**
_______	**A. Electromagnetic Spectrum** Briefly explain electromagnetic radiation and point out the different types - X rays, UV, visible light, IR, and radio waves. Mention that the difference in energy is because of their differences in wavelength.
_______	**B. What is Ultraviolet light?** Show students where UV light occurs in the electromagnetic spectrum. Explain that there are 3 kinds of UV light, depending on the wavelength (UVA, UVB, UVC).
_______	**C.What Happens when UV Light Reaches Earth's Atmosphere?** Students discuss Ozone depletion.
_______	**II. Demonstrations**
_______	**A. The Integumentary System** Discuss the different parts of skin. Refer to the Ein-o skin model.
_______	**B. How is UV light dangerous?** Ultraviolet light has more energy than visible light, and can damage living cells. Discuss UV radiation and skin.
_______	**III. Testing UV Blocking Materials.** Show the students the necklace made from UV beads and demonstrate the UV bead sensitivity to UV light by shining the black light on the necklace. Each group will use the purple UV-sensitive beads and a black light to test a variety of items. The items tested are a control bead, SPF 45 sunscreen, sunglass lens, a piece of T-shirt, medication bottle.
_______	**IV. Review Results** Ask students to look at the observation sheets while you review the results with them.
_______	**V. Making a UV-sensitive bead bracelet** Students make a bracelet from UV-sensitive beads that they get to keep. The beads will detect UV radiation.
_________	**VI. Optional (if time permits). How Is UV Light Useful?** Discuss how UV lights can be used. Examples are to kill bacteria, attract bugs, detect forgeries, detect bodily fluids in forensic work.

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.

Complete teacher/school information on first page of manual.

1. Make sure the teacher knows the VSVS Director's (Paige Ellenberger) office number and email (in front of manual).
2. Exchange/agree on lesson dates and tell the teacher the lesson order (**any changes from the given schedule need to be given to Paige in writing (email)**).
3. Since this is your first visit to the class, take a few minutes to introduce yourselves. Mention you will be coming three more times to teach them a science lesson.

1. Before the lesson:

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

1. What are the three categories of UV radiation and what are the main differences between them?
2. What are some uses for UV light?
3. What are some ways UV light can be blocked?
4. Which items protected the bead from the UV light and which did not?

2. During the Lesson:
Here are some Fun Facts for the lesson

- -Ultraviolet light actually means "beyond light" because it is beyond the visible light that humans can see. The word "ultra" comes from Latin, as ultra means "beyond."
- -Bees can see UV light! They use it to see which flowers to pollinate when the UV radiation is reflected off of the flower petals.
- -UV light can be used with special powder to find fingerprints and shoe prints that help forensic scientists solve crimes.
- -Too much exposure to UV rays causes a person's skin to wrinkle and sag faster than normal. This is why you should wear sunblock when going outside in the sun!

Fun Facts about skin:

- Your body has about 19 million skin cells!
- Your skin loses about 30,000 to 40,000 old skin cells a day. But don't worry! Your skin keeps making cells. New skin cells last for about a month before they fall off.
- On 1 square inch of skin, we have 650 sweat glands!
- Skin cells change shape. They start fat and square, but as they move to the top of the epidermis, they get flatter until they finally flake off!
- All the dead skin cells are on top! You have about 18-23 thin layers of dead skin cells!

Unpacking the Kit – what you will need for each section

For Part I Introduction and Part II

II.B The Integumentary System

8 Skin models, 16 handouts (Electromagnetic Spectrum)

For Part III. Testing UV Blocking Using UV Sensitive Beads

32 goggles for students and 5 for VSVS members
8 goggles for student testing, 16 Black Lights, 16 1/2 sheets of white paper towels, 16 Instruction Sheets
1 necklace made from UV-sensitive beads
16 Ziploc bags containing:
6 UV-sensitive beads that turn purple in UV light (in mini bag), 1lens from a pair of sunglasses, 1 piece of T-shirt material, 11-oz wide-mouth bottle for SPF 45 sunscreen, 1medication bottle 1 paper towel, 2 pieces of acetate sheet, 2 Q-tips
For clean-up: 1 Ziploc bag marked for used acetate sheets, sunscreen coated UV beads and Q-tips

For Part V. Making a UV-sensitive bead bracelet

32 pieces of braid for stringing beads - each one is tied off on one end with one UV bead
32 1oz cups, 1 jar beads (about 150, 5 per student)

Divide students into pairs

Your Notes:

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I. Introduction

Learning Goals:
- Students identify where UV light falls on the electromagnetic spectrum.
- Students discuss ozone depletion and its effect on UV light reaching earth.

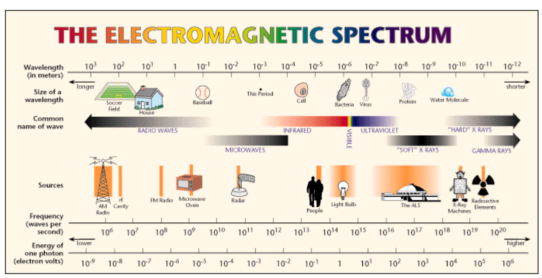
One VSVS team member should write the following vocabulary words on the board while the others are giving each student an Electromagnetic Spectrum handout:
integumentary system, electromagnetic spectrum, visible light, ultraviolet light, SPF, ozone fluorescence, phosphorescence

A. What is the Electromagnetic Spectrum (EM Spectrum)?

Tell students that energy travels to earth from the sun as electromagnetic radiation.
Tell the students to look at the EM spectrum on the handout.

- The **electromagnetic spectrum** is the arrangement of all the different types of electromagnetic waves.
- Discuss briefly (**not more than 3 minutes**) the different parts of the electromagnetic spectrum.
- Point out that there are several different types of waves – radio, microwave, infrared, visible, ultraviolet, x-rays and gamma rays. These waves have different wavelengths, frequencies and energies. Fun mnemonic: Raging Martians Invaded Venus Using X-ray Guns
- Tell students that the light we see is **visible light.** It appears to be white, but is made up of many colors.
- **Point out that the wavelengths longer than the visible red are called infrared and the waves shorter than violet are called ultraviolet.**
- Tell the students that today's lesson will be focusing on **ultraviolet light** (UV light).

- Point out the region in the electromagnetic spectrum where ultraviolet light occurs.



Source: http://www.lbl.gov/MicroWorlds/ALSTool/EMSpec/EMSpec2.html

- Tell students to look at the Visible Light/UV Light diagram (below) and point out:
  - Visible light has wavelengths ranging from 400 to 700 nanometers (1nm = 1 X 10-9 m).
  - UV light has wavelengths from 220 to 400 nanometers.

- Draw a wave on the board and show the students how a wavelength is measured.

Your Notes:

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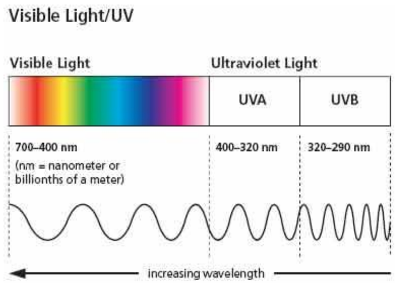

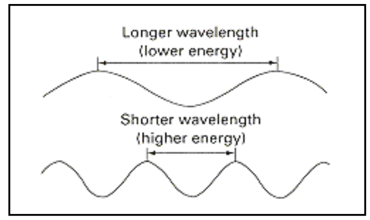

longer wavelength **shorter wavelength**

B. What is UV light?

- UV stands for Ultraviolet, a portion of the light spectrum that is beyond the violet light that we can see with our eyes.
    - Humans cannot see UV light.
    - UV waves have shorter wavelengths and higher energy than visible light.
    - Ultraviolet light is produced by the sun.

C. What happens when UV Light reaches the earth's atmosphere?

- Most UV radiation is absorbed by the ozone layer in the stratosphere or reflected back into space. In the upper atmosphere, ozone is a "good" gas, since it screens out dangerous UV rays. But close to ground it is a pollutant and can act as a greenhouse gas.
- Ozone is naturally formed in the atmosphere when UV rays react with O_2 to make O_3.
- An ozone hole forms over Antarctica every spring (this has happened since the late 1970s). Ozone loss in the polar regions during the winter and spring can be as great as 50-70 % of what is normally present.
- Ozone depletion is primarily caused by chlorine contained in chlorofluoro carbons (CFC's). The production of CFC'has been strictly regulated, since 1987 and 30 years later the hole over Antarctica is gradually filling up.
- BUT new research has shown increasing levels of CFC's since 2012 (from an unknown source), AND decreasing levels of ozone over countries near the equator.

II. Activities and Demonstration

Learning Goals:
- Students describe instances in UV light which it is helpful and harmful
- Students use a model to identify which layers of skin can be damaged by UV light

A. The Integumentary System [in-teg-yuh-men-tuh-ree]

Ultraviolet light has more energy than visible light, and can damage living cells. Skin cancer is the most common type of cancer in the US. It is estimated that 90% of non-melanoma skin cancers are associated with exposure to UV radiation from the sun.

Ask students if they know what the integumentary system is?

Skin, hair and nails make up the **integumentary system.**

The skin is the body's largest organ.

Pass out the skin models – 1 per group of 4.

Your Notes:

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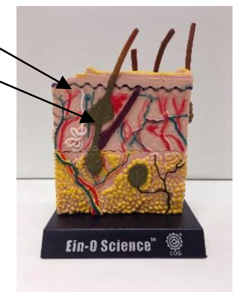
Ask students to give some important functions of skin.

Its purpose is to protect the body from damage, infection and drying out.

It has two main layers: the inner layer, called the dermis, and the outer layer, called the epidermis.

Point out the following layers in the model:

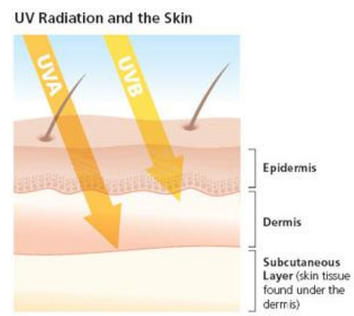
- The **epidermis:**
  - Forms the protective, waterproof layer of the skin.
  - Makes melanin, which is what gives skin its color.
  - It also protects the skin from ultraviolet (UV) ray damage from the sun by absorbing and scattering the energy
- The **dermis:**
  - contains sweat glands which help regulate body temperature
  - nerve fibers which help you feel things around you
  - hair follicles and blood vessels.



B. How is UV light dangerous?

Like visible light, Ultraviolet light has many different wavelengths. There are three categories of UV radiation: UVA, UVB, and UVC. .

UVA rays can age us and **UVB rays** can burn us. Overexposure to either can damage the skin.



UVA: (at 400-315nm) is the closest to the visible light

UVA rays penetrate deep into the dermis, the skin's thickest layer.
Unprotected exposure can lead to premature skin aging.
UVA contributes to and may even initiate the development of skin cancers.

UVB: (315-290nm) is mostly absorbed by the ozone layer in the atmosphere.

The amount of UVB light that reaches the ground depends on where the sun is in the sky, **the amount of ozone in** the atmosphere, and the cloudiness of the sky. On a clear summer day, the maximum amount of UVB radiation occurs around midday, and so the most intense sunburn radiation occurs between the hours of 10am - 4pm.

UVB rays will usually burn the superficial layers of your skin.
When UVB light damages DNA, our cells might not work correctly. Sometimes this makes the cells grow uncontrollably, a condition called cancer.
UVB light also damages the tissue in our eyes and can cause cataracts.

UVC: (290-220nm) is very dangerous, but it is all blocked by the earth's atmosphere (the ozone layer).

How do you know if your skin has received too much UV light?

- It turns red and becomes tender, i.e., you get a sunburn.

We should block as much UV light from our bodies as possible.
Ask students if they know ways we can block UV light. Answers should include:

- sunscreen, long sleeves and pants, wide brimmed hats, sunglasses, and staying in the shade.
- Glass in windows transmits less than 10% of sun-burning UV light.
- <u>**AVOID TANNING BEDS – THEY USE UV LIGHT**</u>

Your Notes:

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- Watch for the UV Index – it is issued daily for your zip code and predicts the level of solar UV radiation and indicates the risk of overexposure on a scale from 0 (low) to 11 or more (extremely high). A special UV Alert may be issued for a particular area if the UV Index is forecasted to be higher than normal.
- AVOID TANNING LOTIONS – THEY DO NOT PROTECT YOUR SKIN.

UV light damages many things other than human skin. One of the vitamins added to milk is vitamin D. If vitamin D is exposed to UV radiation, it will begin to break down and not be useful to the body anymore. The white milk jug may offer slightly more protection than glass and Purity Dairy puts its milk into yellow containers
Prescription bottles are usually colored to prevent UV light from degrading the medicines by photochemical reactions.

III. Testing UV Blocking Using UV Sensitive Beads

Learning Goals:
- Students participate in a controlled experiment to test the effectiveness of different materials in blocking UV light.
- Students use evidence from experiments to draw conclusions about how to best prevent sunburns

Show the students a small "black light" and turn it on.
- Explain that the purple glow is light from the visible, not the ultraviolet part of the EM spectrum.
- A **black light** emits UV radiation in the 300-400nm range plus some visible light.

Tell students we are going to use beads that contain a chemical that absorbs the UV light and reemits it as visible light.

For VSVS Information: Black lights work in the same way that fluorescent lights work. Both bulbs contain mercury vapor inside the bulb.
When the bulb is electrified, electrons of the mercury atoms are excited and when they return to the ground state, UV light is emitted.
In **fluorescent bulbs**, the UV light is absorbed by the white coating (the phosphor) and reemitted as white light.
In **black lights,** a different phosphor is used to produce the UV light, as well as a special glass for the bulb which blocks almost all of the visible light.
The color change in the beads involves a dye molecule absorbing UV energy to produce a different geometric isomer of the molecule. When the UV energy is removed, the color slowly fades as the dye molecule rotates back to the more stable form. Since the color fades slowly, this is an example of **phosphorescence**

- Divide the students into pairs and give each pair one of the UV lights.
- Show the students a string of UV detecting beads. Point out that all the beads are white.
- Expose the necklace to a portable UV light, until the beads have turned color.
- Point out the purple beads in the necklace and tell the students that they will be using just the purple beads for this experiment because these change to a more intense color than the others.

What does sunscreen do?

Your Notes:

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- Since most students should be familiar with sunscreen and SPF, keep this discussion brief.
- Most students will probably answer that sunscreens keep you from getting sunburned.
- The only light waves affected by sunscreen are those in the UV range. There are special chemicals in sunscreens that absorb the UV light, preventing it from reaching your skin.

How do you know how well a sunscreen blocks UV light?

- All sunscreen is labeled with an **SPF** (**S**un **P**rotection **F**actor) number that indicates how well it absorbs UV light.
- For example, an SPF of 45 means that it should take 45 times longer for skin damage to occur as it would on unprotected skin.
- Doctors recommend that everyone (even those with dark skin) wear a sunscreen with an SPF of at least 15 whenever they are in the sun.
- Doctors recommend using sunscreen that is labelled as "broad spectrum", since they protect your skin from both UVA and UVB rays. Show the students the picture of the different sunscreens and point out the SPF caption and if it is a broad spectrum sunscreen (protects you from both UVA AND UVB radiation)

Who should wear sunscreen?

- Everyone! "Although darkly pigmented persons develop skin cancer on sun-exposed sites at lower rates than lightly pigmented persons, UV exposure will still increase their risk for developing skin cancer."

Distribute the following to each group:

The Ziploc bags of materials to be tested
1 blacklight

Distribute a pair of goggles to every student, and VSVS members. (The goggles will block any UV radiation from reaching eyes.)

A. Demonstrating the procedure:

- Tell the students they will be testing several items to see how well they block UV radiation. They will be using the UV-sensitive beads and observing their color change. This is phosphorescence, since the beads absorb the UV light but continue re-emit visible light even when not exposed to UV
- Tell them they need to have a **control** bead to compare the effect of the protection. The control bead will be completely exposed to the UV light, whereas the other beads will have some protection.
- Show the students the observation sheet, the positions to place the beads and materials to be tested. Demonstrate steps 1-3 and then tell the students to do the experiment.
  1. Put 3 beads in the squares on the first row of the observation sheet, and cover with the lens of a sunglass, and the piece of T-shirt. Leave one bead uncovered – this is the control bead. Tell the students they will be exposing these items to UV light and will be observing the color changes that occur.
  2. Hold the UV light about 2-4 inches above the beads (make sure all beads have UV light shining on them at the same time).
  3. When the control bead has turned purple, turn the UV light off and remove the lens and material. Observe and record the color of the beads.

Your Notes:

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- Tell students to collect the sunglass lens and piece of T-shirt and beads and put them back into the Ziploc bag. Do this before moving on to the next experiment.
- Demonstrate steps 4-7 and the have students do the experiment.
    4. Place the remaining 3 beads in the squares on the 2nd row. Show the students the acetate sheets, Q-tips and the container of SPF 45.
    5. Dip a Q-tip in the sunscreen, spread a good amount on the acetate, and immediately put on top of the bead. (Tell them this is important to prevent the sunscreen from drying out.) **Emphasize that they should try to avoid getting any sunscreen on the paper and beads, since it is difficult to wash off.**
    6. Place a medication bottle over one bead
    7. Hold the UV light about 2-4 inches above the beads (make sure all beads have UV light shining on them at the same time).
    8. When the control bead has turned purple, turn the UV light off and remove the lens and material. Observe and record the color of the beads.

Tell the students to carefully remove the acetate sheets covered with sunscreen and place them on the paper towel with the Q-tips. Keep all sunscreen away from lens etc. A VSVS member will collect all materials with sunscreen on them and put them in the marked bag. We will wash beads for reuse.

Ask students how they could test if the goggles prevent UV light from damaging their eyes.
By placing a UV detecting bead inside up-turned goggles and holding the goggles over the black light.
If there is time, have the students perform this test with the extra goggles.

IV. Review

Learning Goals:
- **Students participate in a controlled experiment to test the effectiveness of different materials in blocking UV light.**
- **Students use evidence from experiments to draw conclusions about how to best prevent sunburns**

Note: Ask the students to look at the observation sheets while you review the results with them.
- Does **sunscreen** really work? *Yes*
- Do **sunglasses** block UV? *Yes*
- Does **clothing** protect you from UV light? *Yes*
- Does the orange colored prescription bottle protect pills from UV light? *Yes*

V. Making a UV-Sensitive Bracelet

Give each student a cup of 5 UV beads and 1 piece of braid.
- Tell the students to string the beads onto the braid. After they have finished stringing the beads, they should make a bracelet by putting the untied end through the hole in the bead on the tied-off end and tying a knot.
- When they are finished, they should shine their black light on the beads. (The beads take a few minutes to develop the full color.) Notice that the beads continue to glow after the black light is removed.
- Tell the students they get to keep the bracelet and should use it to measure the amount of UV radiation on sunny days. They could keep a diary of their results – trying different times of the day and different times of the year – summer vs. winter.

Your Notes:

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VI Optional (if time permits). How can UV light be useful?

Ask the students if they know any uses for UV lights.

- Ultraviolet lights are used by forensic scientists to detect bodily fluids.
  - They can also be used to kill bacteria.
  - Bug Zappers use UV light to attract insects.
  - UV lamps are used to detect fake dollar bills ($5 and up).
- Tell students to look at their handout sheet.
  - The bottom picture shows a copy of a $20 bill that has been exposed to UV light.
  - Notice the **fluorescent strip.** Some chemicals absorb UV light and then re-emit the energy as visible light – this is fluorescence
  - This strip can be seen on the bill in visible light, but fluoresces only under UV light.
  - Bills of different denominations have strips that fluoresce different colors and are at different positions on the bill. The $1 bill does not have a strip.

Clean-Up and Return of the Kit:

1. Students should place everything (except the acetate, paper towel and Q-tips used for sunscreen) in their plastic bags.
2. A VSVS member will collect all materials with sunscreen on them and put them in the marked bag.
3. VSVS members will collect and return everything to the VSVS lab.

Note: Be sure to collect all black lights. Count to make sure you have 16. Check that they are turned off and place them back in the kit box before you go on with the next sections.

Written by: Pat Tellinghuisen, Program Coordinator of VSVS 1998-2018, Vanderbilt University
Rachel Shevin, VSVS student volunteer Vanderbilt University
Dr. Mel Joesten, Emeritus Professor of Chemistry, Vanderbilt University

Reference: "Putting UV-Sensitive Beads to the Test" by Terre Trupp, Journal of Chemical Education, Volume 78, Number 5, May 2001 p. 648a&b.
Additional Resources Consulted: American Academy of Dermatology
http://www.cdc.gov/mmwr/preview/mmwrhtml/rr5104a1.ht

Your Notes:

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UV Light and Skin Protectant Observation sheet

NAME ________________________________

Vocabulary words:
Integumentary system, Electromagnetic spectrum, visible light, ultraviolet light, fluorescence, phosphorescence, SPF, ozone

Bead covered by sunglasses	**CONTROL** (Un-covered Bead)	Bead covered by t-shirt

Bead covered by prescription container	**CONTROL** (Un-covered Bead)	Bead covered by SPF 45 sunscreen

Ultraviolet Light - Observation Sheet

	No color change	Light purple	Darker Purple
<u>Experiment 1.</u> Control UV Bead			
UV bead covered with sunglass lens			
UV bead covered with T-shirt			
<u>Experiment 2.</u> Control UV Bead			
UV bead under presciption container			
UV bead under SPF 45 sunscreen			

Note: If there is no change in the original color of the bead, then the bead has absorbed no UV light. If the color of the bead has changed to a dark purple, then it has absorbed a lot of UV light.

Review questions:
What **SPF** sunscreen should be worn when outside?
Does clothing protect your skin from UV light?

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Crazy Traits

Spring 2019

Goal: To understand some basic principles of heredity by building creatures determined by flipping a coin for different traits.
This lesson was adapted from CPO Crazy Traits Lesson.
Fits TN State standards: 7LS3.1, 7LS3.2, 7LS3.3,

VSVSer Lesson Outline:

_______ **I. Introduction**: VSVS team will explain some background about heredity, including the concept of dominant and recessive traits, as well as some history about Gregor Mendel. It is very important to include the definition of an allele, genotype and phenotype as these words appear often in the lesson.

_______ **II. Determining the Genotype**: Students will flip coins to determine the gender and 13 traits so that they can build their creatures. VSVS team will draw a Punnett Square on the board and have the students help fill it in so that students will be able to write down the genotype of their crosses on their observation sheet.

________ **III. Building Your Creature**: Students will assemble their creature by matching the inherited genotypes with the corresponding phenotype. A chart with the genotypes and phenotypes will be on their Instruction Sheet.

________ **IV. Dominant and Recessive Traits and Clean-up**

________ **V. Optional Activity**: Students will taste PTC paper.

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

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

Crazy Traits Lesson Quiz

1. Define the following terms: heredity, gene, dominant allele, recessive allele, genotype, phenotype
2. Fill in the following Punnett square and identify which outcomes are homozygous and which are heterozygous:

	T	t
T		
t		

2. During the Lesson:
Here are some Fun Facts for the lesson

- Humans have at least 30,000 genes, which are found on chromosomes (single pieces of coiled DNA).

- Humans have 23 sets of chromosomes in each cell in their body that determine traits like height and eye color as well as more complex traits like personality and likelihood of developing disease.
- If you uncoil all the DNA you have in all your cells, you could reach the moon 6000 times.
- Gregor Mendel developed his famous laws of inheritance in the 1800s, though their profound significance was not recognized until the beginning of the 20th century.

UNPACKING THE KIT - <u>What you will need for each section</u>

For Introduction Part II. Determining the Genotype

32 Observation Sheets, 16 Instruction Sheets, 8 sets of 3 laminated parts sheets, 8 circular tins containing 1 red X/X coin, 1 blue T/t coin, 1 green T/t coin, and 1 black X/Y coin, 16 handouts with pictures of mother Crazee (Tt) and father Crazie (Tt)

For Part III. Building Your Creature

8 sets Crazy Traits creatures

For Part IV: Dominant and Recessive Traits and clean-up

8 sets of 3 laminated parts sheets

For Part V: Optional Activity – Tasting PTC Paper- 1 container PTC paper

I. Introduction

> **Learning Goals:**
> - **Students distinguish between the terms allele genotype, and phenotype, and can describe their role in inheritance**
> - **Students describe the role of dominant alleles, recessive alleles, incomplete dominance, and codominance in determining phenotype**

- Write the following terms on the board: **heredity, gene, dominant allele, recessive allele, allele**
- Ask students: *What things about you distinguish you from other people?*
  - Some examples should include hair color, height, eye color, etc.
  - These are examples of **traits**.
- Ask students: *Why do you look different from your parents? Your siblings?*
  - The passing of traits from parents to their children (offspring) is a process known as **heredity**.
- Ask students: *What are traits?* A trait is a characteristic of an organism.

Tell students to raise their hand if they have the trait you name:

curly hair
straight hair
freckles
blue eyes
taller than the average person their age

Tell students that these are just a few of the many traits they possess.

Ask students *if they have heard of Gregor Mendel*.

- Mendel is called the Father of Heredity because he discovered some of the very first ideas of heredity based on experiments with peas.

Your Notes:

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- Mendel discovered that when pea plants with different traits were crossed, their offspring would exhibit one trait more often than the other.

- Now we know that traits are controlled by a basic unit of heredity called a **gene**.
  - **Genes** are located on the genetic material called **DNA**.
    - **Different forms of the same gene are called alleles.**
    - For each trait, one **allele** comes from your mother and one from your father.
    - The alleles you have depend on the alleles your parents have and on chance.

- The combination of alleles is called a **genotype**. It determines a trait.
  - That trait that an offspring shows physically is called the **phenotype.**

- **Dominant** alleles trump **recessive** alleles. This means that if an offspring has one dominant version of the gene and one recessive version of the gene, the dominant allele will be the one that shows. Example: if you have one allele for brown eyes and one allele for blue eyes, your eye color will be brown. This is because the brown eye gene is dominant over the blue eye gene.
- Today, we will explore how different traits can be produced in offspring when two parents are crossed.

II. Determining the Genotype

Learning Goals:
- **Students distinguish between the terms allele genotype, and phenotype, and can describe their role in inheritance**
- **Students understand and use Punnett Squares as a visualization tool for predicting the likelihood that an offspring will have a particular genotype**

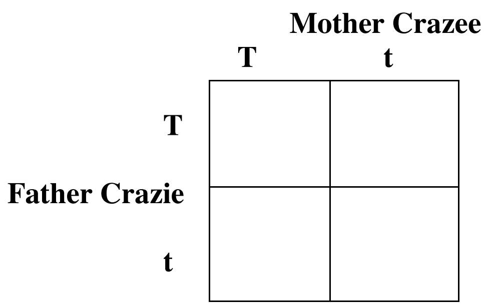
1. Show the students the mother Crazee and father Crazie.
   - Tell them that both parents have the same genotype, Tt for all traits.
     - **Usually, the capital T represents the dominant allele, and the lowercase t represents the recessive allele**
   - Each group is going to create an offspring from these same parents.
2. Tell students that the first step is **to determine the sex of their offspring.**
   a. Remove all coins from the tin.
   b. Choose the male sex chromosome coin. It has an X on one side and a Y on the other.
   c. Now select the female sex chromosome coin, it should have an X on both sides.
   d. Place the two coins in the tin, shake them and toss them onto the table.
   e. Record your results on your Observation Sheet.
3. Students will now determine the genotypes for all the traits that the offspring creatures will inherit.
   a. Tell students to look at the sperm coin (green) and the egg coin (blue).
   b. Notice that the coins have a T (dominant allele) on one side and a t (recessive allele) on the other (= genotype Tt).
   c. Ask students: What do the letters on the coins represent? *Alleles*
   d. Place these coins in the tin (remove the sex chromosome coins.)

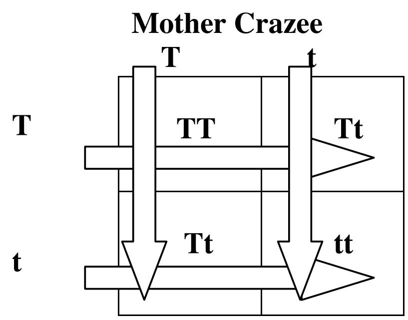
Your Notes:

Observation Sheet

Trait	Genotype of mother for the trait	Genotype of father for the trait	Genotype of offspring (after tossing coins)	Phenotype of offspring
Gender	XX	XY		
Skin color	Tt	Tt		
Leg	Tt	Tt		

4. A Punnet square can help students visualize all the possible combinations of alleles from parents. In this lesson, dominant alleles have capital T's and recessive alleles have lowercase t's.
   Draw the following Punnett square on the board, and have the students help you to fill in the different combinations.





Ask students what is the chance of inheriting the genotype tt? (25%)

5. The first trait the students will shake for is skin color:
   a. Place the blue and green coins in the tin.
   b. Shake the coins and toss them onto the table.
   c. Write your results (TT, Tt or tt) for each trait on the observation sheet.
   d. Continue for all traits.

6. Now we will use the genotypes from the observation sheet to make our creatures.
   a. Have students look at the instruction sheet. The table contains the key for the phenotype for each of the genotypes. Remember the **ph**enotype is the **ph**ysical appearance of a genotype and genotype is the genetic code,
   b. Match the genotype for your creature with the corresponding phenotype on the key. Have students fill in the last column on their observation sheet.

Team members should circulate the classroom to see if there are any questions and make sure students are filling in their table correctly.

Your Notes:

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Trait	Genotypes and Phenotypes
1. Gender	XX: female; XY: male
2. Skin Color	TT: red; Tt: purple, tt: blue
3. Leg	TT: short; Tt: short; tt: long
4. Foot	TT: webbed; Tt: webbed; tt: talons
5. Arms	TT: long; Tt: long; tt: short
6. Hands	TT: paws; Tt: paws; tt: claws
7. Eye Color	TT: red; Tt: one red, one green; tt: green
8. Eyebrows	TT: unibrow; Tt: unibrow; tt: separate
9. Beak	TT: trumpet; Tt: trumpet; tt: crusher
10. Ears	TT: elephant; Tt: elephant; tt: mouse
11. Antenna	TT: long; Tt: long; tt: short
12. Antenna Shape	TT: knob; Tt: knob; tt: star
13. Tail	TT: long; Tt: short; tt: none
14. Wings	TT: no wings; Tt: no wings; tt: wings

III. Building Your Creature

Learning Goals:
- **Students distinguish between the terms allele genotype, and phenotype, and can describe their role in inheritance.**
- **Students describe the role of dominant alleles, recessive alleles, incomplete dominance, and codominance in determining phenotype.**

- After students have completed their table, they can use their kit to build their creature.
- Each phenotype should be matched to the correct body part.

Building hints:
1. The female bodies have the rounded part closest to the head. The male bodies have the pointed part closest to the head.
2. Put the skin on; then, attach the head and leg.
3. Next, find the correct foot, place the foot on the base and put the creature in the base.
4. Finish matching the correct traits with the body parts.
5. Have students compare their creatures with other creatures from the class.

Note: If the students are rowdy, this may be difficult and last too long. Set a time limit, or have VSVS team members hold up the creatures for the class to see.

- Ask students: Do any of the creatures look the same? *They shouldn't*.
- Ask students: Even though the parents are the same, why do the creatures look different?
  - Students may have difficulty with this, but illustrate that this is similar to siblings. Siblings have the same parents, but sometimes look quite different.
  - This is because the phenotype or trait is determined by the genotype of the parents **and** by chance.

Your Notes:

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- Even with only 13 traits (humans have many more traits), none of the creatures were identical. This is because the chance of getting two identical creatures is very small.
- For VSVS information: On the other hand, siblings look more similar to their parents than other unrelated adults. This is because humans have many more traits and some are linked and inherited together

- Have students report whether their creatures were male or female. Write each total on the board.
  - What number would we have expected? *50%*
  - Is the number the same? *It may be, but it may not be. Our prediction was made because there was a 50% chance of getting a female, and a 50% chance of getting a male. This does not mean that we will get exactly 50% males and 50% females all the time.*

IV. Dominant and Recessive Traits and Clean up

- **Tell students to look at the Table on their Instruction sheet.**
- Ask students: *Which traits are **dominant traits**? Which traits are **recessive traits**?*
- Make two columns on the board, one for dominant and one for recessive. The answers are below.

Dominant	**Recessive**
short legs	long legs
webbed feet	talons
long arms	short arms
Paws	claws
Unibrow	separate eyebrow
trumpet beak	crusher beak
elephant ears	mouse ears
long antenna	short antenna
knob antenna shape	star antenna shape
no wings	wings

- Students should notice that three traits aren't dominant or recessive.
  - Skin color and tail are examples of **incomplete dominance**, where the heterozygous condition (Tt) produces a different condition all together. So, red + blue = purple.
  - The eye color is an example of **codominance** where both traits are expressed together. In this case, the heterozygous condition produces one red eye (T) and one green eye (t).

Important: As students finish with their creatures, have them take the creature apart and place each part on the parts sheet to make sure they return every part.
One volunteer will lead the optional activity while the other volunteers go around the room for clean up!
Important: Make sure that you have **all** of the parts in each box **before** you leave the classroom

Your Notes:
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V. Optional Activity – Tasting PTC Paper

- Learning Goals: Students describe the role of dominant alleles, recessive alleles, incomplete dominance, and codominance in determining phenotype

- Have each student taste a small piece of PTC paper.
- **Ask students** *to raise their hand if they can taste the paper and to put their heads down on the desk if they cannot taste the paper*.
- Write down the number of students who can taste the PTC paper and the number of students who cannot taste the PTC paper down on the board.
- Explain to students that the ability to taste PTC is genetic.
- Ask the students *if they think that the ability to taste PTC is dominant or recessive based on the numbers on the board*. **Dominant**

For VSVS Information - Disclaimer: Higher proportions of having a trait does not mean it is dominantly inherited. For example, polydactylism is a condition associated with having more than 5 fingers or toes on each hand/foot. Although not common, some forms are caused by dominant alleles. Huntington's disease is another dominantly inherited condition that causes breakdown of brain cells over time. These conditions are dominant but not usually passed on because they negatively impact an organism's fitness.

Lesson written by:
Pat Tellinghuisen, VSVS Program coordinator 1998-2018 Vanderbilt University
Modifications by Vinccent Huang, VSVS board member 2016-2019
Reference: CPO manual

Your Notes:

Crazy Traits
Observation Sheet

Trait	**Genotype of mother for the trait**	**Genotype of father for the trait**	**Genotype of offspring (after tossing coins)**	**Phenotype of offspring**
Gender	XX	XY		
Skin color	Tt	Tt		
Leg	Tt	Tt		
Foot	Tt	Tt		
Arms	Tt	Tt		
Hands	Tt	Tt		
Eye Color	Tt	Tt		
Eyebrows	Tt	Tt		
Beak	Tt	Tt		
Ears	Tt	Tt		
Antenna	Tt	Tt		
Antenna shape	Tt	Tt		
Tail	Tt	Tt		
Wings	Tt	Tt		

Look around at the creatures for other groups. Do any of the creatures look the same?

List the dominant traits below.

List the recessive traits below.

Are there any traits that are not dominant or recessive?

Crazy Traits
Observation Sheet Answers

Trait	Genotype of mother for the trait	Genotype of father for the trait	Genotype of offspring (after flipping)	Phenotype of offspring
Gender	XX	XY		
Skin color	Tt	Tt		
Leg	Tt	Tt		
Foot	Tt	Tt		
Arms	Tt	Tt		
Hands	Tt	Tt		
Eye Color	Tt	Tt		
Eyebrows	Tt	Tt		
Beak	Tt	Tt		
Ears	Tt	Tt		
Antenna	Tt	Tt		
Antenna shape	Tt	Tt		
Tail	Tt	Tt		
Wings	Tt	Tt		

Look around at the creatures for other groups. Do any of the creatures look the same?
No, and they should not, even though all of the parents had the same genotype. This is because the creatures are determined by genotype of parents and by chance.
List the dominant traits below.
Short legs, webbed feet, long arms, paws, unibrow, trumpet beak, elephant ears, long antenna, knob antenna shape, no wings.
List the recessive traits below.
Long legs, talons, short arms, claws, separate eyebrow, crusher beak, mouse ears, short antenna, star antenna shape, wings.
Are there any traits that are not dominant or recessive? *Skin color, tails and eye color do not display typical inheritance. See lesson for explanation.*

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Effect of Carbon Dioxide on the Environment

Spring 2019

Goals: To understand the three states of matter and the six examples of changes of state.
To investigate the effect of carbon dioxide dissolved in "ocean" water.
To investigate the role of carbon dioxide in the formation of caves.
Fits TN Standards: 7PS1.6, 7ESS3.1, 7ESS3.2

Lesson Outline

_____ **I. Introduction**
A: Carbon Dioxide Facts
Give students some background information on CO_2.
B: Background Information about Dry Ice
1. How is Dry Ice Made?
Students learn how dry ice is made, what it is used for and how cold it is.
2. **The States of Matter: Solids, Liquids, and Gases**
Introduce the three states of matter and the six examples of changes of state.

_____ **II. Comparing Dry Ice to H_2O Ice**
Activity: Students observe a piece of dry ice and a piece of H_2O ice that have been placed in separate ziploc bags. The ziploc bag containing dry ice inflates from CO_2 gas given off when dry ice sublimes. Dry ice doesn't leave behind a liquid when it melts because it sublimes.
What is the Greenhouse Effect?
Use the student handout to discuss the greenhouse effect.

_____ **III. Effect of CO_2 in Oceans.**
Universal Indicator is used as an indicator to show that carbon dioxide can make water more acidic. Students infer that natural rainwater is slightly acidic because of carbon dioxide.

_____ **IV. Effect of CO_2 on Land.**
Acid added to a Tums tablet illustrates how caves are formed, and show sthe effect of acidic water on seashells and corals.

_____ **V. Review**

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

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) Name all six changes of state.
2) Think of several basic "uses" of carbon dioxide in every-day life. (Hint: plants, carbonated drinks, air, Halloween, fire)

Your Notes

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3) What properties of dry ice distinguish it from regular ice?
4) Why is rainwater **slightly** acidic?
5) Why does dry ice bubble in water?
6) Describe the reaction of carbon dioxide with water. How does this effect oceans? What happens when there is an increase in carbon dioxide in the atmosphere ?
7) How is **acid rain** different from rainwater? What causes **acid rain**?

2. Use these fun facts during the lesson:

- The famous candy "Pop Rocks" are made by highly pressuring the candy with carbon dioxide. When you eat it, the candy dissolves and the carbon dioxide is released, which creates popping sounds.
- Dry ice cannot be stored in inflexible containers (like glass) because the buildup of sublimed gas would cause the container to explode.

Note: In this lesson use the words carbon dioxide and the term CO_2 interchangeably so the students will become familiar with both.

Materials:

1	trash bag for used cups
16	Thermometer diagram (in binder)
1	12oz styrofoam cup for H_2O ice
3	12oz styrofoam cups dry ice
32	ziploc snack bags
32	plates
5	tongs for volunteers to use
5	pairs work gloves for volunteers to use
16	dropper bottles of universal indicator
1	liter of ocean water
16	6oz. (squat) clear plastic cups (to be 1/3 filled with ocean water)
16	6 oz clear cups (to be 1/3 filled with dilute acid)
16	Tums tablets
1	liter water (tap)
2	500mL bottles 0.1M HCl
35	Observation Sheets
17	Instruction Sheets and thermometer diagram
17	Handouts containing Universal Indicator color charts, cave formation diagrams plus greenhouse effect
1	Answer Sheet for VSVS Team (in sheet protector)
1	box goggles (32 plus 5 for volunteers)

Unpacking the Kit:

Part 1: Distribute the Instruction sheets (containing thermometer diagram), plus Handout containing Universal Indicator chart, Greenhouse effect diagram, cave formation diagram to pairs of students. Distribute an observation sheet to each student.

Part 1I: Distribute goggles to all students.

Give each PAIR a plate, 2 ziploc snack bags 1 tsp of H_2O ice, 1 piece of dry ice

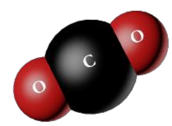
Your Notes

Part 1II: Distribute 1 dropper bottle of universal indicator and 1 6oz. (squat) clear plastic cups 1/3 filled with ocean water,
Part 1V: Distribute 1 6 oz clear cups containing 1 Tums tablet. VSVSers will add dilute acid (0.1M HCL) .

While one team member starts the introduction, another should write the following vocabulary words on the board:
dry ice, change of state, sublimation, deposition, vaporization, freezing, melting, condensation, climate change, cave formation
Whenever possible, refer to vocabulary words throughout the lesson and during review.

For this lesson: One VSVS volunteer needs to 1/3rd fill 16 10 oz cups with "ocean" water for Part III
One VSVS volunteer needs to 1/3rd fill 16 10 oz cups with limewater for Part IV.
Divide the students into pairs.

IA. Carbon Dioxide Facts



- Write and draw the CO_2 molecule on the board (it is on the instruction sheet as well)
- Write CO_2 on the board and ask students: What is CO_2? *carbon dioxide*
- Ask students: What do you know about CO_2?
  Accept student responses and share the following information if it is not mentioned in the discussion.
  - Humans inhale oxygen and exhale CO_2.
  - Plants use CO_2 to carry out the process of photosynthesis. The photosynthesis reactions of plants convert carbon dioxide to oxygen.
  - CO_2 is solid at -108° F or -78° C.
  - CO_2 is a gas at room temperature.
  - CO_2 dissolves in water and is what gives fizz to carbonated drinks.
  - Carbon dioxide is a greenhouse gas in the atmosphere. It helps keep the atmosphere warm with the greenhouse effect.

Today we are going to use dry ice as a source of carbon dioxide.

1B. Background Information about Dry Ice

1. **How is Dry Ice made?**
   Dry Ice is made by collecting carbon dioxide gas that is formed as a by-product from industrial activities such as fermentation, oil refinery activities.

For VSVS information only: Then the carbon dioxide-rich gas is pressurized and refrigerated until it liquefies. Next, the pressure is reduced. When this occurs some liquid carbon dioxide vaporizes, causing a rapid lowering of temperature of the remaining liquid. As a result, the extreme cold causes the liquid to solidify into a snow-like consistency. Finally, the snow-like solid carbon dioxide is compressed into small pellets or larger blocks of dry ice

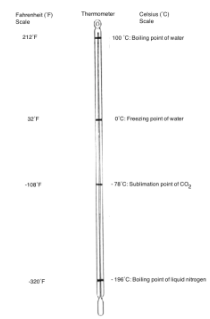
Your Notes

- Ask students: What is dry ice used for?

  Accept student responses and share the following information if it is not mentioned in the discussion.
    - Dry Ice is used in meat lockers to keep meat frozen.
    - Dry Ice is used in the manufacturing of plastics, chemicals, beverages, pharmaceuticals.
    - It is used in theaters to create a fog effect.

- **Discussion of Dry Ice Temperature**

Use the thermometer diagram to help students understand the temperature of dry ice (how cold it is) by comparing the markings for the boiling point of water, freezing point of water. Note that there is no temperature given for the boiling point of liquid CO_2 because it does not exist at normal pressure.



2. **The States of Matter: Solids, Liquids, and Gases**

- Most substances have three states of matter that are observable at normal conditions

  (1 atmosphere of pressure and 20°C).
- Ask students what the 3 states of water are? *Ice (solid), liquid, and water vapor (gas).*
    - Tell students that carbon dioxide also has 3 states, but that only 2 exist at normal conditions: a solid (called dry ice) and gas.
- There are 6 processes that are involved in changes of state: **freezing, melting, vaporization, condensation, deposition**, and **sublimation.**
    - Draw the following diagram on the board, omitting the italicized processes.
    - Ask students to name the physical processes that lead to changes of state, and add them to the diagram. Be sure to include the following information in the discussion, and refer to the thermometer to show students where the various points are on the thermometer

Note: Write the different states on the board. Ask the students to identify the processes involved in each change of state, and add to diagram.

Solid ***(melts)*** **→Liquid** ***(vaporizes)*** **→Gas**

Gas **(*condenses*)** **→Liquid** **(*freezes*)** **→Solid**

Solid **(*sublimes)*** **→Gas**

Gas ***(deposits)*** **→Solid**

- Liquids can change to solids by **freezing**.
    - The freezing point of water is 32°F or 0°C.
- Solids can change to liquids by **melting**.
    - The temperature where a solid melts to a liquid is called the melting point.

Your Notes

- A liquid changes to a gas by **vaporization** (boiling).
    - When water boils, steam rises off the top. The steam is water vapor, which is water as a gas.
    - The vaporization point of water is 100°C or 212°F.
- A gas changes to a liquid via **condensation**.
    - This change of state is responsible for the droplets of water that form on a lid when a boiling pot of water is covered.
- **Sublimation** occurs when a solid changes state to a gas without going through a liquid phase.
    - Dry ice sublimes at -78°C or -108°F.
- **Deposition** is the change from gas to solid. (One example is snow that forms in clouds. Water vapor changes directly to ice without first becoming a liquid.)

II. Comparing Dry Ice to H_2O Ice

Safety Note: Students should not hold pieces of dry ice. The temperature of dry ice is -78° C, and students could get frostbite burns if their skin is in contact with dry ice for more than a few seconds.

Materials to be given to each PAIR:
2 goggles
1 plate
2 ziploc snack bags
1 tsp of small pieces of H_2O ice
1 piece of dry ice

- Distribute the materials to pairs.
- Tell students to put their goggles on and keep them on until the end of the lesson. VSVS members should also put on goggles.
- VSVSers place 1 tsp of H_2O ice in a bag and a piece of dry ice in the other ziploc bag. The bags are placed on the plate.
- Tell students to **close the ziploc fastener** on the bag.
- **Remind students that they should not touch the dry ice.**
- Ask students to observe both pieces of ice in the ziploc bags for a few minutes.
- Record their observations on the Observation Chart. Make sure that the students:
    1. Describe what happens.
    2. Record the changes of state that occur.

Observation 1: *The dry ice ziploc bag will inflate whereas the water ice bag does not.*
Explanation: Room temperature is around 20°C. Dry ice sublimes at -78°C so CO_2 gas is filling the bag.
Ask students: What changes of state have occurred? *Dry ice **solid** to CO_2 **gas** by **sublimation**. Water ice **solid** to **liquid** water by **melting** .*

- Tell students to open the ziploc bags and carefully empty the pieces of dry ice and ice onto the plate.
- Tell students to leave the pieces of ice and dry ice on the plate, do not move them, but

Your Notes

observe them periodically to see what happens over time.

Observation 2: Later when the two pieces have disappeared, the students will notice a puddle where the H_2O ice was and there will be no puddle where the dry ice was.
Explanation: Students should recall that dry ice sublimes (becomes a gas without passing through the liquid phase), thus it does not leave a puddle. Regular ice leaves a puddle because solid ice turns to a liquid at temperatures above 0°C.

> **Note:** Share the following information with the class: carbon dioxide actually does have a liquid state which can be observed at room temperature and 5 atmospheres of pressure.

Observation 3: *"Smoke" comes off the dry ice.*
Explanation: This is caused by tiny ice particles that form because the cold carbon dioxide gas coming off dry ice is cooling the water vapor in the air enough to cause it to condense into tiny droplets.
Ask students what the changes of state are:
CO_2 gas ***sublimes*** *from the solid dry ice, and is cold enough to* ***condense*** *water vapor (in the air) to liquid water droplets.*
Emphasize that CO_2 gas is colorless and is invisible.
The white "smoke" is condensed water vapor.

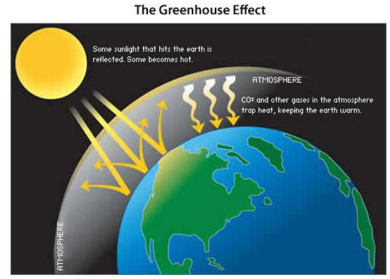
Remind students that all these changes of state are physical changes, not chemical changes.

What is the Greenhouse Effect?

- Ask the students what they know about the effect of carbon dioxide on the atmosphere? Bring up these points if the students do not:
    - Carbon dioxide is a greenhouse gas and traps infrared radiation which can be converted to heat. Other molecules can also trap heat (e.g. water vapor and methane), but carbon dioxide is considered the main problem because it is being added to the atmosphere by human activity.
    - Air contains a very small amount of carbon dioxide (about 0.03%).

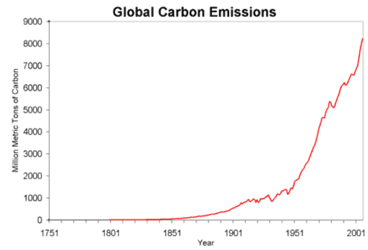
Background:
Up until the 1800s and the start of widespread use of fossil fuels, humans were a minimal contributor to global warming. The Earth itself (volcanic eruptions, deep sea rifts) was a bigger source of increased carbon dioxide.
Since the Industrial Age, people have contributed additional carbon dioxide to the atmosphere by burning fossil fuels like coal, oil, and natural gas.
Scientists believe that increased concentration of carbon dioxide in the atmosphere is causing global warming.

The Greenhouse Effect



Explain what a greenhouse gas is: The sun's rays pass through the atmosphere, hit the earth, and are reflected back as heat. This heat is absorbed by greenhouse gases, such as carbon dioxide, in the atmosphere.

Your Notes



- Tell students to look at the handout that has the diagram showing the greenhouse effect and the graph showing the increase in carbon dioxide since the Industrial Age.

III. The Effect of CO_2 in Oceans

Tell students that increasing amounts of CO_2 in the atmosphere also effects the oceans.
Write on the board: **carbon dioxide sink, acidification**

- Ask the students what they know about the effect of carbon dioxide on the oceans?
  - Ocean water is naturally slightly basic (tell students to look at the pH chart) because it contains dissolved minerals.
  - Oceans are called **sinks** for CO_2. Most of the CO_2 in the oceans becomes carbonic acid. Point to the equation on their Instruction sheet.

    CO_2 + H_2O → H_2CO_3
    Carbon dioxide water carbonic acid
  - Oceans have absorbed between 1/3rd and ½ of the carbon dioxide released by humans since 1850, and this has slowed the rate of climate change.
  - Oceans contain 50 times more carbon dioxide than air. Water in the oceans can remove CO_2 directly from the air. These natural mechanisms can remove 10 billion tons of CO_2 per year.
  - The amount of carbon dioxide in the oceans has also increased since the Industrial Age.
  - Burning of fossil fuels is putting about 25 billion tons into the air annually, so there is a net increase of 15 billion tons.

Distribute the following materials for each pair:

1 10 oz. clear plastic cup 1/3 full of "ocean" water
1 dropper bottle of universal indicator
1 Universal Indicator chart
1 piece of dry ice

Show the students the universal indicator and tell them that it is used to measure the acidity of liquids. Have them look at the Universal Indicator chart.

- In neutral solutions, such as distilled water, the indicator is green.
- In acidic conditions, it will turn yellow, then red.
- In basic solutions it will be blue. Ocean water is naturally slightly basic.

NOTE: Acid rain is much more acidic, having a pH below 5.6.
Acid Rain is caused by acids formed when polluting gases NO_2, SO_2 and SO_3 gases react with water.

Tell the students to put a squirt of indicator into their cups.
Tell students to note the color *It should be green.* A more intense color is preferable.
Add a piece of dry ice to it.
Note color changes.

Your Notes

Observation: *The indicator changes color.*
Students should observe that the indicator changes color as the carbon dioxide dissolves in water. See color chart change. **This is an example of a chemical change**
Explanation: When dry ice is added to water, the warmer temperature of the water causes the dry ice to produce carbon dioxide gas bubbles, some of which dissolve in the water. When carbon dioxide dissolves in water it forms **carbonic acid,** a weak acid that acidifies the solution.

Tell students to look at the equation on their Instruction sheet:

CO_2	+	H_2O	$\rightarrow$	H_2CO_3
Carbon dioxide		water		carbonic acid (a weak acid)

Ask students if they can think of consequences of dissolving increasing amounts of carbon dioxide in ocean waters? *It will make the oceans more acidic*.

- Acidification of the oceans has been occurring since the Industrial Revolution, over the same time span that an increase in CO_2 gas in the atmosphere has been noted.
- The change in acidity so far is small, but greater changes are expected.
- Acidification can adversely affect marine life. Increasing acidity can make it difficult for marine organisms to form skeletons and shells

There are other observations that students can make. Discuss these as a class and move on to the next section on cave formation.

Dry ice gives off bubbles when it is added to water.
Changes of State: Dry ice solid to CO_2 gas (sublimation)
Explanation: The water is warm enough (room temp. is approximately 20°C or 68°F) to cause the dry ice to sublime and produce carbon dioxide gas bubbles.

A white fog appears over the water in the top of the glass.
Changes of State: Water vapor (gas) to liquid water droplets (condensation).
Explanation: The air above the water (and in the room) contains water vapor. When the temperature of the air is lowered by the cold carbon dioxide gas, the water vapor condenses to small water droplets (a fog) or ice particles (smoke) that are suspended in the carbon dioxide gas. Point out that the fog is white even though the solution in the cup is colored. Emphasize that carbon dioxide gas is colorless.

The white fog stays in the top of the glass and any white fog that leaves the glass goes down along the side of the glass rather than up in the air.
Explanation: Carbon dioxide is heavier than air, water droplets are heavier than air, and cold air is heavier than warm air. Fog that went out of the glass went down rather than up into the air.
Tell students that dry ice is often used to create smoke and fog-like effects in movies and at concerts.

Fog that goes down along the glass disappears near the bottom of the glass.
Changes of State: Liquid water droplets vaporize to gaseous water vapor.
Explanation: The carbon dioxide fog has warmed up enough to vaporize the water, leaving only carbon dioxide which is colorless. The CO_2 warms up to the dew point temperature so the water droplets are converted to water vapor, causing the fog to disappear.

Your Notes

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IV. Effects of CO_2 on Land

Tell students that CO_2 in water also affects the land.
Remind students that carbon dioxide dissolves in water to produce carbonic acid.

CO_2	+	H_2O	→	H_2CO_3
Carbon dioxide		water		carbonic acid (a weak acid)

Tell students that rainwater seeps down through soils where CO_2 levels can be 10 to 100 times that of the atmosphere. This is because certain bacteria decompose organic material which releases CO_2 in the process. Since soil is not as open as the atmosphere, much of this CO_2 gets stuck, causing water trickling down to become much more acidic than the rainwater.

Ask them if they know of any examples of CO_2 affecting land. Answers may include:
Acidic rain (but incorrect -stress that normal rain is not strongly acidic, and not a result of CO_2, but instead is a result of acids formed when polluting gases NO_2, SO_2 and SO_3 gases react with water.), weathering of rocks.

If students don't mention **dissolving rocks**, tell them that rainwater can dissolve certain types of rock. Tell students that there is a rock called limestone that contains the **mineral calcite**. Ask them if they know where this rock can be found. *Answer: It is common anywhere that used to be shallow ocean. Middle Tennessee has lots of limestone because it used to be a shallow ocean*.
The mineral calcite is composed of calcium carbonate.

Experiment – Effect of Acid on Calcium Carbonate

Materials for each pair:
6 oz clear cup containing a Tums tablet
2 500mL bottles 0.1M HCl

> Background Information: Calcium carbonate reacts with carbonic acid (carbon dioxide in water) to form soluble calcium bicarbonate. Corals and shells are composed of calcium carbonates.
> The equation for this step is:
> $CaCO_3(s) + CO_2(g) + H_2O \rightarrow Ca(HCO_3)_2\,(aq)$
> Note: (s) = solid, (g) = gas, (aq) = dissolved in water

Tell students that the Tums tablet is a good model of the calcite mineral, since it is also made of calcium carbonate. Tums tablets are commonly used to aid acid indigestion, and heartburn, since they can help neutralize excess acids in the stomach.
Note: the acid used in this model to simulate the effect of carbonic acid on calcium carbonate is dilute hydrochloric acid.

Activity:
VSVSers will give each pair of students a cup containing a Tums tablet.
Other VSVSers will pour the dilute acid into the cups (about 1/3rd full)
Ask students what they observe? *Students should see bubbling from the Tums tablet disintegrating*.

Real world application

Your Notes

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Tell students that what they have observed illustrates the process of how a cave is formed AND what can happen to shells and corals in acidic solutions.
Explain cave formation by asking the students to look at the drawing on their observation sheets and explaining what happens (without using chemical equations).

- Explain that the process of cave formation is very slow, taking many thousands of years depending on the size of the cave. Cave formation occurs as follows:
  - Rain dissolves some CO_2 from the air as it falls.
  - The rain water collects even more CO_2 as it percolates through soil (because of the concentrated amounts in the soil).
  - When the rain water hits limestone (calcium carbonate, the same as the Tums tablet), the acidified water begins to dissolve the rock. Ask students: Why? *(If you explained it clearly they should respond that the carbonic acid in rain water reacts with calcium carbonate to form calcium bicarbonate, which is soluble).*
  - As the limestone dissolves, the aqueous calcium bicarbonate is carried away by underground rivers. The contour of a cave is left behind.
  - Many times, caves have stalagmites and stalactites, which form on the floor and ceiling of the cave respectively. This occurs when water containing the dissolved calcium bicarbonate evaporates, causing calcium carbonate to precipitate (reverse of equation 2).
  - (For VSVS'ers: this is LeChatelier's Principle at play).

V. Review

Review the changes of state and ask the students to give example from today's experiments.

What does **sublime** mean? *A solid goes directly to a gas state without becoming a liquid.*

- What is dry ice? *solid carbon dioxide*
- How cold is dry ice? *–78 ^oC. Refer to the thermometer diagram.*
- What happens when dry ice is dropped into water? *Bubbles of CO_2 are given off, a cloud forms above the water, the cloud stays in the container instead of floating in the air, if any of the cloud falls out of the container it floats down and disappears.*

Note about solutions used for "simulated" ocean water and "simulated" rain water

We are using a pH 10 solution for the "simulated" ocean water to lengthen the time needed for color changes for Universal Indicator. This allows students time to observe the color change from blue (basic) to green (neutral) to yellow (acidic) when a piece of Dry Ice is added to the solution. The average pH of ocean water is 8.1. When a solution with this pH is used in this activity, the addition of a piece of Dry Ice causes the Universal Indicator color changes to occur so fast that the green color for a neutral solution can't be seen.

Lesson written by: Dr. Melvin Joesten, Chemistry Department, Vanderbilt University
Pat Tellinghuisen, Program Coordinator for VSVS1998-2018, Vanderbilt University
Susan Clendenen, Teacher Consultant, Vanderbilt University
Heather Day, Assistant for VSVS, Vanderbilt University

Your Notes

Effect of Carbon Dioxide on the Environment
Observation Sheet Student's Name_________________________

Lesson Activity	Observations
II. Comparing Dry Ice to H_2O Ice a) What happens to the dry ice in the bag? The regular ice?	
b) What happened to the dry ice left on the plate? The regular ice?	
III. Carbon Dioxide in Ocean Water What color did the Universal Indicator solution turn when dry ice was added? What does this tell you about the effect of carbon dioxide dissolved in ocean water?	
IV. Cave Formation What happens to the Tums when acid was added to it What does this tell you about the effect of carbon dioxide dissolved in rain water on limestone, coral reefs and sea shells ?	

Effect of Carbon Dioxide on the Environment
Observation Sheet
Answer Sheet

Lesson Activity	Observations	Change of State
II. Comparing Dry Ice to H_2O Ice in a bag A What happens to the dry ice in the bag? B The regular ice?	A Ziploc bag with dry ice fills with gas (CO_2). B. Ziploc bag with ice doesn't change in size	A. solid to gas (sublimes) B. none
II. Comparing Dry Ice to H_2O Ice on the plate A What happened to the dry ice left on the plate? B the regular ice?	A1 Dry ice CO_2 changes from solid to gas A2 Water vapor in air is cooled by dry ice to form tiny particles of ice water, seen as "smoke(water vapor). B Water ice melts	A1. solid to gas (sublimes) A2. gas to liquid to solid B. solid to liquid
III. Carbon dioxide in Ocean Water What color did the Universal Indicator solution turn when dry ice was added? What does this tell you about the effect of carbon dioxide dissolved in ocean water?	From blue to green to yellow to red.	No change of state This is a chemical change
IV. Cave Formation What happens to the Tums when acid was added to it What does this tell you about the effect of carbon dioxide dissolved in rain water on limestone, coral reefs and sea shells ?	The Tums tablet fizzes in the acid and disintegrates.	No change of state This is a chemical change.

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

Inheritance and Blood Typing

Spring 2019

GOAL To introduce the students to the study of genetics through an activity dealing with blood typing
Fits TN standards: 7.LS3.3

VSVSer LESSON OUTLINE

_______ **I. Introduction**
Give a brief introduction to the volume and the components of blood in the body.

_______ **II. Red blood cell demonstration**
Show the models of red blood cell and explain what an antigen is and how it relates to blood type.

_______ **III. The Kidney Problem**
Students will perform an experiment to determine the blood types of family members to see if they qualify as kidney donors for their mother/wife.

_______ **IV. Analysis**
Using the data obtained from part III, the students will analyze their results.

_______ **V. Optional: Blood genetics and Punnett squares**
Explain how blood type is determined genetically and show how Punnett squares can be used to determine genotype. Provide definitions for genotype, phenotype, dominant, and recessive.

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.
Students will work in pairs for the activity.

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

1. Explain the differences in the antigens and antibodies among the blood types.
2. a. Which blood types can Type A donate to and receive transfusions from? Why?
   b. Type B? c. Type AB? d. Type O?
3. Why is blood typing so important? What would happen if someone received a transfusion of an incompatible blood type?
4. Finish this Punnett square to determine the possible blood types of the children from parents with AO and BO types:

	A	O
B		
O		

2. During the Lesson:
Here are some Fun Facts for the lesson – for VSVSers

- Usually a person has one blood type for their whole life, but infection, malignancy (like cancer), or autoimmune diseases can cause a change. A bone marrow transplant may also do this; the patient will eventually convert to the donor's blood type.
- Blood typing is important during pregnancies; if the father has an incompatible blood type to the mother, care must be taken so that the mother doesn't develop antibodies against the baby's blood that attack the baby's RBCs (hemolytic disease of the newborn (HDN) **-** has to do with Rh + and -, but not covered in lesson). Mothers often receive shots (Rho(D) immune globulin) to prevent this from happening.
- Blood typing also used to be heavily used for paternity tests and in criminal investigation. Actual blood isn't always necessary; about 80% of the population secretes the antigens/proteins/antibodies/enzymes characteristic of their blood type in other bodily fluids and tissues. A serologist could, for example, be able to tell if the source of a sample of blood came from the victim or the criminal. DNA testing, though, is used for detailed analysis.
- Type O is generally considered the "universal donor" type because it does not contain A or B antigens that would be rejected by A, B, or AB blood types. (However, there are other antigens that come into play, so in real life situations, hospitals categorize blood type on a more detailed level.)
- Even though Type O is recessive, it is the most common blood type because it is the ancestral form; the A and B antigens are mutations.
- Infants get antibodies passively from their mothers but start making them independently when they are three months old.
- Clinical trials are being done on a bacterial enzyme that can convert RBCs of A, B, and AB types into O by stripping away their antigens. This could have profound implications for blood transfusions.

UNPACKING THE KIT – what you will need for each part

FOR PART I. INTRODUCTION:

1 1 liter bottle (containing liquid with red dye)

FOR PART II RED BLOOD CELL DEMONSTRATION:

Set of blood cell models (Wards Blood Typing Demonstration Model, 14W8327)
Each set for VSVS demonstration contains

- 1 plastic bag containing 2 plastic blood cells each with a blue “A” peg (the A antigen) attached and 1 yellow Y –shaped pieces (the “B” antibodies)
- 1 plastic bag containing 2 plastic blood cells each with a yellow “B” peg (the B antigen) attached and 1 blue Y -shaped pieces (the “A” antibodies)
- 1 plastic bag containing 2 plastic blood cells each with both a blue “A” peg (the A antigen) AND a yellow “B” peg (the B antigens) attached. (No antibodies included)
- 1 plastic bag containing 2 plastic blood cells with no antigens attached and 1 blue Y -shaped piece (the “A” antibody) and 1 yellow Y –shaped piece (the “B” antibody)

15 Blood Types handouts.

FOR PART III. THE KIDNEY PROBLEM:

15 24-well plates, 15 plates, 15 blood testing worksheets, 30 safety goggles
15 ziploc bags with
1 dropping bottle containing fake blood labeled “Mrs. Sanderson”
1 dropping bottle containing fake blood labeled “Mr. Sanderson”
1 dropping bottle containing fake blood labeled “Jill”
1 dropping bottle containing fake blood labeled “Jack”
1 dropping bottle containing “Anti-A serum”
1 dropping bottle containing “Anti-B serum

Your Notes:

I. INTRODUCTION

Learning Goals:

- Students describe the composition of blood, including how antigens and antibodies determine blood type in different individuals.
- Students understand the relationship between antigens and antibodies, and identify which blood types are compatible as donors and receivers

Write the following vocabulary words on the board:
Antibodies, antigen, Punnett square, blood cell, ABO blood type
Ask students: How much blood do you think is in the human body? *About 5 liters of blood*.
At this point, **show the students the 1-liter bottle** and tell them that their bodies contain about 5 liters of blood.

Ask students: What is in blood? (What makes up blood?)
Briefly Explain::
Blood is composed of a liquid (plasma) and solids (red and white blood cells and platelets).
Plasma—yellow-colored liquid that is primarily (92%) water; makes up most of blood volume (55%). It carries metabolites, nutrients, hormones, wastes, salts and proteins throughout the body and contains the anti-A and anti-B antibodies
Red blood cells (RBCs)—shaped like a donut, but without a hole; carry oxygen; give blood the red color; make up 40-45% of blood.
White blood cells (WBCs)—cells that are a part of the immune system. There are several types of white blood cells; one can produce **antibodies** which can help destroy bacteria and viruses.
Platelets—cell fragments that are responsible for clotting and scab formation
Tell the students that this activity will focus on characteristics of red blood cells.

Ask students: What are the different blood types? *There are four blood types: A, B, AB, and O*. Blood typing is one way of characterizing what kind of blood someone has. It is determined by the type of **antigen** that is present on the surface of the red blood cells.

II. RED BLOOD CELL DEMONSTRATION

MATERIALS

Set of blood cell models (Wards Blood Typing Demonstration Model, 14W8327)
Each set for VSVS demonstration contains

- 1 plastic bag containing 2 plastic blood cells each with a blue "A" peg (the A antigen) attached and 1 yellow Y –shaped pieces (the "B" antibodies)
- 1 plastic bag containing 2 plastic blood cells each with a yellow "B" peg (the B antigen) attached and 1 blue Y -shaped pieces (the "A" antibodies)
- 1 plastic bag containing 2 plastic blood cells each with both a blue "A" peg (the A antigen) AND a yellow "B" peg (the B antigens) attached. (No antibodies included)
- 1 plastic bag containing 2 plastic blood cells with no antigens attached and 1 blue Y -shaped piece (the "A" antibody) and 1 yellow Y –shaped piece (the "B" antibody)

15 Blood Types handouts.

1. The red blood cell has proteins on its surface that determines what blood type a person is. These proteins are called **antigens.** An antigen is a chemical tag that the body can identify with antibodies. An antigen is any substance to which the immune system can respond.

Your Notes:

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2. Blood cells are named by the type of antigen on its surface.

3. Show students the bags of blood cells. Tell students that the red donut shape is a model for a red blood cell. The pegs are the **antigens** (blue is the "A" antigen, yellow is the "B" antigen). The Y-shapes are the **antibodies.**

4. Show students the bag containing blood cells that have the blue pegs attached – this red blood cell now has an **"A" antigen**. It is a **Type A blood cell.** It also contains a yellow Y-shaped anti-B antibody present in the plasma.

5. Show students the bag containing blood cells that have the yellow pegs attached. This red blood cell has a **"B" antigen –** it is **a Type B blood cell.** It also contains a blue Y-shaped anti-A antibody present in the plasma.

6. Show students the bag containing blood cells that have the blue AND yellow pegs attached. Ask the students what type of blood cell this is. ***Answer: an AB blood cell.*** There are no antibodies in the plasma.

7. Show the students the bag containing the fourth blood cell that does not have any antigens on its surface. Ask the students what type of blood cell this is. ***Answer: an O blood cell*** (if the students are confused, tell them to think of the cell has having zero (O) antigens on its surface)
   There are both A and B antibodies present in the plasma and in the plastic bag.

8. Tell students to look at Table 1 on the handout to see a comparison of the different types of blood cells side-by-side, and the relative representation of blood types in the American population.

9. The A-B-O blood typing system classifies blood by the **antigens** on the red blood cell surface and the **antibodies** in the plasma.

   a) **Antibodies** help in removing unwanted things from the blood. If the immune system encounters an antigen that is not found on the body's own cells, it will launch an attack against that antigen. Many antibodies recognize antigens by being able to match the shape and remove them by binding to the antigens – seen as clumping in the experiment.

   b) If a person has blood cells with **the A antigen**, that person will have antibodies against the B antigen in the plasma. It does not normally have antibodies against cells with the A antigen. If it had A antibodies, it would be like having a double agent on your team – the A antibodies would attack the healthy cells in your body. This is the basis of autoimmune disorders where the body's immune system incorrectly attacks healthy cells.

   c) If someone has blood cells with the **B antigen**, that person has antibodies against cells with the **A antigen** in its plasma.

   d) People with AB blood cells do not have antibodies to either type of antigen, while people with O blood cells have antibodies to both.

Your Notes:

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Tell students to look at the Table 1in the handout.

Table 1

ABO Blood Type	Contains Antigens A	Plasma Contains Antibodies	Agglutination (clumping) occurs with
A	A	Anti- B	Anti-A serum only
B	B	Anti-A	Anti-B serum only
AB	A and B	None	Both Anti-A serum and Anti-B serum
O	None	Anti-A and Anti-B	Neither

Blood Transfusions and Organ Transplantations

When transfusions of blood were first attempted, some were successful but others often fatal. For a blood transfusion to be successful, the recipient's blood must not contain antibodies that will react with/attack the antigens in the donor's blood.

Important: donor's blood contains ONLY red blood cells. There is no plasma in the donor's blood. Therefore, there are no antibodies in the donor's blood.

If a person has blood type A, he cannot receive Type B or Type AB blood because the Anti-B antibodies in the recipient's blood will bind to the B antigen in the donor's blood and destroy these cells.

10. Ask students if they can determine what types of blood a person with Type B blood **can receive?** ***O and B.***
11. Ask students if they can determine what types of blood a person with Type AB blood **can** receive? ***A, B, AB, O. This person is called a universal recipient.***
12. Ask students if they can determine what types of blood a person with Type O blood **can receive?** ***Only O.*** But this person can give blood to anyone and is called a universal donor.

These results are summarized in the Table 1 on the handout.

This **reactivity** demonstrates why people have their blood tested prior to a transfusion or transplantation. If blood types are not compatible, any transferring of blood can have negative consequences.

III. THE KIDNEY PROBLEM

Learning Goals:

- Students understand the relationship between antigens and antibodies, and identify which blood types are compatible as donors and receivers
- With support, students identify a method for determining blood type

Your Notes:

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MATERIALS
15 24-well plates
15 ziploc bags with
    1 dropping bottle containing fake blood labeled "Mrs. Sanderson"
    1 dropping bottle containing fake blood labeled "Mr. Sanderson"
    1 dropping bottle containing fake blood labeled "Jill"
    1 dropping bottle containing fake blood labeled "Jack"
    1 dropping bottle containing "Anti-A serum"
    1 dropping bottle containing "Anti-B serum"
15 plates
15 blood testing worksheets
30 safety goggles

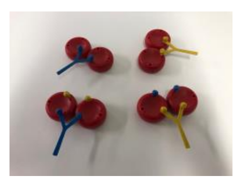
Tell students that they will work to determine the blood type of the members of a "family" so that a donor match can be found.

Scenario: Mrs. Sanderson developed a rare kidney disease that causes the kidney to lose function over time. She had been doing well for the past few years, but it seems that her kidney is starting to decline rapidly. Her doctors suggest that the best way for her to live a long life is for her to receive a kidney transplant. Her family has just been informed of her health situation and they are asked to undergo a blood test. If a family member shares her blood type and is willing to donate a kidney to her, Mrs. Sanderson will probably be able to get better.

(OPTIONAL INFO) The major function of the kidney is to filter the blood to get rid of various wastes such as urea. People only need one kidney in order to live normally.

Blood Typing
Tell the students that they will be blood test specialists.
Remind the students that the blood samples are not really blood.
In order to donate a kidney (or blood), there must be a match of blood types between the donor and the recipient to prevent the recipient's antibodies from attacking the donor cells.
There is a simple test to determine blood type of the recipient and possible donor.
    Antisera are made containing either A antibodies or B antibodies. Serum is a "purified" form of plasma that contains the antibodies.
    When the antiserum is added to each blood sample, it can react with the blood sample and cause the red blood cells to clump together – this is called **agglutination.** This would eventually result in clogged blood vessels and cause kidney failure.

Show students the two red blood cell models that are labelled Type "A". Connect the two blue antigens on the cells with the blue anti-A serum Y- shape. This represents the reaction of clumping or agglutination.
Similarly, show the students the two red blood cell models that are labelled Type "B". Connect the two yellow antigens on the cells with the yellow anti-B serum Y- shape.



These results are summarized on the handout in Table 1 and the "Clumping" picture.

a. If the blood clumps in the anti-A serum and not the anti-B serum, then the blood type is A.
b. If it clumps for the anti-B and not for the anti-A, then the blood type is B.
c. If it clumps for both, the blood type is AB.
d. If there is no clumping, then the blood type is O.

Your Notes:

Divide the students into pairs. Pass out safety goggles and one set of materials to each pair of students.

Tell the students:

1. Put on the goggles and wear them until after they finish using the dropper bottles.
2. Look at the 24-well plate and find the column labels 1-6 (across the top) and the row labels (A-D) (along the side). You will be using columns 1-4 and rows A and B.
3. Add a squirt of Mrs. Sanderson's samples to 1A and 1B (the first two wells in Column 1). Replace the cap on the bottle labelled Mrs. Sanderson.
   Add a squirt of anti-A (blue) to the first well in row A(1A). Observe whether a precipitate (or cloudiness) occurs. If a precipitate or cloudiness occurs, enter a "+" in square A-1 in the table below. If nothing happens, enter a "–".
   Add a squirt of anti-B (yellow) to 1B, recording a "+" or a "– " in the appropriate square of the table.
4. Repeat for Mr. Sanderson's samples in 2A and 2B (the first two wells under Column 2) and enter your results. Replace the cap on the bottle labelled Mr. Sanderson.
5. Repeat for Jill's samples to 3A and 3B (the first two wells under Column 3). Record the results. Replace the cap on the bottle labelled Jill.
6. Repeat for Jack's samples to 4A and 4B (the first two wells under column 4). Replace the cap on the bottle labelled Jack. Replace the caps on the bottles labelled anti -A and anti-B.
7. Determine the blood type:
   -- **Type A** will clump only in anti-A serum
   -- **Type B** will clump only in anti-B serum
   -- **Type AB** will clump in both anti-A and anti-B serum
   -- **Type O** does not clump when either serum is added.

IV. ANALYSIS

Learning Goals: Students understand the relationship between antigens and antibodies, and identify which blood types are compatible as donors and receivers

1. From the data that was obtained, tell the students to figure out what the blood type of each family member is. The instructions on how to determine the blood type of each individual are written in the last step of the handout. Write these answers on the board and/or share with the class.
2. From the data tables, ask the students if any of Mrs. Sanderson's family will be able to donate their kidney to her.

Because Mrs. Sanderson's blood clumps in the anti-A serum, she is blood type A. In the same way, Mr. Sanderson has type B blood and Jill has type AB blood and they will not be able to donate. However, Jack, with type O blood, can and does donate a kidney, saving his mother's life.

V. BLOOD GENETICS AND PUNNETT SQUARES

Learning Goals: Students use Punnett squares and basic genetics to construct an explanation for why people have certain blood types

Your Notes:

We can tell what blood type someone has by analyzing their red blood cells for their antigens.

Ask the students: *Can we tell what possible blood types an offspring will have just by knowing what his or her parents' blood types are?* Accept answers. Yes, by using a Punnett square.

Ask the students: *What do you think determines which antigens end up on the red blood cells?*
Tell students that antigens and thus, blood type, are determined by the genes (on chromosome 9!) that get passed on from parents (in the same way that other traits are passed down from parents).

An individual's ABO type is determined by the inheritance of 1 of 3 alleles (A, B, or O) from each parent.
Explain that each parent has two blood type alleles. This is what's known as a **genotype**.
Each parent will pass on one of these alleles (remember that they have two!) to their child.
These alleles are for the A antigen (blood type A), the B antigen (blood type B) or no antigens (blood type O). The combination of two of these alleles will determine what the blood type will be.

Ask students to determine the possible genotypes of offspring? If they do not know how to use Punnett squares, briefly explain by drawing the square on the board:

1. Draw a Punnett square (Figure 1.) and compare it to a four-square court. The mother's genes are on top and the father's genes are on the left side.
2. The empty boxes are filled by writing the each of the mother's genes in the boxes directly below it and each of the father's genes in the boxes directly to the right of it (figure 2). In this example, the mother has an AA blood genotype, while the father has an AB blood genotype.

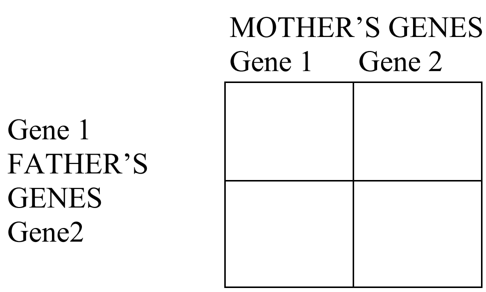


Figure 1. Punnett Square

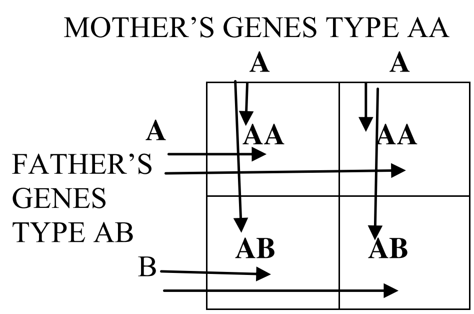


Figure 2. Filling in the Punnett Square

3. After filling in the empty boxes by bringing down both A genes contributed by the mother and bringing over the A and B genes contributed by the father, we find that their offspring will either have an AA genotype or an AB genotype.

4. Review the terms **dominant** and **recessive** with the students.
   In the case of blood, the A and B genes are **co-dominant**. This means that if a child inherits both an A gene and a B gene, both A and B antigens will be found on the surface of an RBC and the phenotype will be AB.
   Individuals who have an AO genotype will have an A phenotype.
   People who are type O have OO genotypes. In other words, they inherited a recessive O allele from both parents.

Your Notes:

5. Tell students to fill out the last line in the observation sheet, assigning possible genotypes to the family members.

6. Tell students to look at the Punnett square on the Handout.

The possible ABO alleles for one parent are in the top row and the alleles of the other are in the left column. Offspring genotypes are shown in black. Phenotypes are red in the brackets.

Parent Alleles	A	B	O
A	AA (A)	AB (AB)	AO (A)
B	AB (AB)	BB (B)	BO (B)
O	AO (A)	BO (B)	OO (O)

http://anthro.palomar.edu/blood/ABO_system.htAsk students:

If Jack has type O blood, what are the genotypes for his mother and father. Have the students fill out their Punnett square using all the possible genotypes for Mr. and Mrs. Sanderson.
For VSVS Information: make sure you know the logic used in determining the possible genotypes.
Since Jack is type OO, he must have the genotype OO. He has to get one O from his mother and one O from his father. So Mrs. Sanderson must have AO and Mr. Sanderson must have BO

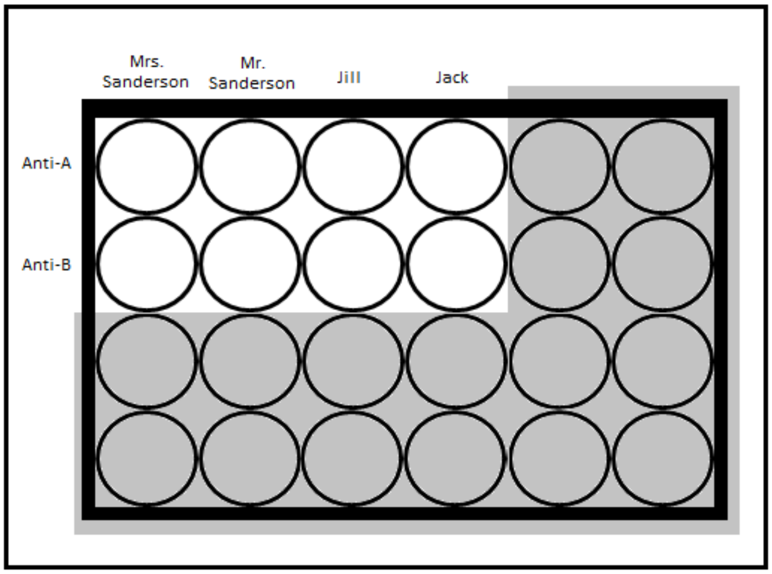
Answer sheet

Blood Typing Lab Data Sheet

	Column 1	Column 2	Column 3	Column 4
	Mrs. Sanderson	**Mr. Sanderson**	**Jill**	**Jack**
Row A Anti-A serum	+ Yes	- No	+ Yes	- No
Row B Anti-B serum	- No	+ Yes	+ Yes	- No
Blood Type (A, B, or O)	A	B	AB	O
Possible Genotype	AA or AO	BB or BO	AB	OO

Written by Josh Beckham, GTF, GK-12 Program, Vanderbilt University
Joe Lopez, Center for Science Outreach and VSVS
Mel Joesten, Professor Emeritus, Vanderbilt University
Pat Tellinghuisen, Program Coordinator 1998-2018, Vanderbilt University
Significant edits by Vincent Huang, Aakash Bansu and Sarah Baumgarten, Undergraduate Students, Vanderbilt University

Blood Typing Lab Data Sheet NAME ___________________________



	Column 1	Column 2	Column 3	Column 4
	Mrs. Sanderson	**Mr. Sanderson**	**Jill**	**Jack**
Row A Anti-A serum **clumping occurs = +** **nothing happens = -**				
Row B Anti-B serum **clumping occurs = +** **nothing happens = -**				
Blood Type (Phenotype) **(A, B, AB or O)**				
Possible Genotype **(AA, AB, BB, AO, BO, OO)**				

Mrs Sanderson

Mr Sanderson

Mrs Sanderson

Mr Sanderson
