7th Grade

Spring 2022 Lesson Plans

Vanderbilt Student Volunteers for Science

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

VOLUNTEER INFORMATION

Team Member Contact Information

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:	Molly Friedman	molly.h.friedman@vanderbilt.edu
	Alex Ruemmler	alex.k.ruemmler@vanderbilt.edu
Secretaries:	Doah Shin	doah.e.shin@vanderbilt.edu
	Neeraj Namburu	neeraj.s.namburu@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: https://studentorg.vanderbilt.edu/vsvs/lessons/

- 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 start the lesson without them.
- 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 used for lessons 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.

Just relax and have fun!

February

SUN	MON	TUES	WED	THU	FRI	SAT
	31 Applications Close	1	2	3	4	5
6	7	8	9 Team Leader Training 4-5 PM	10	11 Next Steps Lesson #1 2-3 PM	12
13 Team Leader Training 4-5 PM	14 5th/7th Grade Training Sessions	15 5th/7th Grade Training Sessions	16 5th/7th Grade Training Sessions	17 5th/7th Grade Training Sessions	18	19
20	21 6th/8th Grade Training Sessions	22 6th/8th Grade Training Sessions	23 6th/8th Grade Training Sessions	24 6th/8th Grade Training Sessions	25	26
27	28 First week of lessons					

March

SUN	MON	TUES	WED	THU	FRI	SAT
	28 First week of lessons	1 First week of lessons	2 First week of lessons	3 First week of lessons	4	5
6	7 **No Lessons** VU Spring Break	8 **No Lessons** VU Spring Break	9 **No Lessons** VU Spring Break	10 **No Lessons** VU Spring Break	11	12
13	14 **No Lessons** MNPS Spring Break	15 **No Lessons** MNPS Spring Break	16 **No Lessons** MNPS Spring Break	17 **No Lessons** MNPS Spring Break	18 Next Steps Lesson #2 2-3 PM	19
20	21 Second week of lessons	22 Second week of lessons	23 Second week of lessons	24 Second week of lessons	25	26
27	28	29	30	31		

April						
SUN	MON	TUES	WED	THU	FRI	SAT
				31	1	2
3	4 Third week of lessons	5 Third week of lessons	6 Third week of lessons	7 Third week of lessons	8 Next Steps Lesson #3 2-3 PM	9
10	11 Fourth week of lessons	12 Fourth week of lessons	13 Fourth week of lessons	14 Fourth week of lessons	15	16
17	18 Lesson make-up week 1	19 Lesson make-up week 1	20 Lesson make-up week 1	21 Lesson make-up week 1	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?

Volunteer FAQ

➔ What is VSVS?

VSVS stands for Vanderbilt Student Volunteers for Science. Members of this organization volunteer to teach hands-on science lessons to 5th-8th grade classrooms in the Metro Nashville School District.

➔ How often are lessons?

Each team teaches 1 lesson per week for 4 consecutive weeks throughout a semester.

➔ What is the time commitment?

Relatively low! Depending on your position, you'll attend between 1-3 training sessions at the beginning of the semester, and each of the 4 lessons take about 1.5 hours (30 minutes to run through each lesson beforehand and 1 hour to teach it).

➔ Who will I be teaching with?

All volunteers are put into groups of up to 3 (based on availability) and assigned to a classroom.
If you have friends that you'd like to be partnered with, be sure to have one group member fill out a separate Partner Application so you can be appropriately matched!

➔ Where will I be teaching?

Your team will be teaching your students over some virtual platform from the same room. VSVS will reserve a room where your team can meet. Social distancing rules and sanitation protocols will be enforced.

➔ What are the lesson dates?

At the beginning of each semester, we send out a group assignment email that contains all of the relevant information for your group. It will have your teachers name and contact information, as well as the names and contact for all of your group members, and the date/time of your lessons.

➔ What if I need to quit VSVS?

If you can no longer fulfill your commitment to VSVS, please reply to one of the emails we've sent you ASAP and let us know so that we can adjust accordingly.

➔ Can graduate students participate in VSVS?

Yes -- you can either join as a regular volunteer and be assigned to a team and classroom OR you can serve as a floating volunteer (that is, if your schedule is very irregular but you know that you'll be available for at least a few of our weeks!). Just note which option you'd like in your application!

For additional questions, feel free to contact the VSVS Educational Coordinator at paige.ellenberger@vanderbilt.edu.

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 GREENWOODAVE **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

Evidence of a Chemical Reaction

Mini-lesson Spring 2022

Goal: To show students evidence of a chemical change and introduce the Law of Conservation of Mass.
Introduces/Reinforces TASS: 7.PS1.4 Analyze and interpret chemical reactions to determine if the total number of atoms in the reactants and products support the Law of Conservation of Mass.

VSVSer Lesson Outline

______ I. Introduction

- Question students about the difference between physical and chemical changes. Explain what constitutes evidence of chemical reactions.
- Demo A – Chemical reactions that give a precipitate.
- Demo B – Chemical reactions that produce a color change.
- Demo C – Chemical reactions that produce a gas.

______ II. Safety Concerns

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

______ III. Determining if a Chemical Change has Occurred

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

______ **Row A: Chemical Reactions That Give a Precipitate (solid)**
Students should realize that if the solution turns cloudy, a solid (precipitate) is forming.

______ **Row B: Chemical Reactions That Involve a Color Change**
Formation of complex ions cause color changes.

______ **Row C: Chemical Reactions That Produce a Gas**
Students look carefully at the bubbles (CO_2) produced in solutions.

______ IV. Review

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

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

Lesson Quiz

1) What are some basic differences between a physical and chemical change? *Answer in Intro*
2) What are signs of a chemical change? *Answer in the end of Intro*
3) What are the major safety concerns in this lesson for students? *Answer in II. Safety Concerns*
4) What is a precipitate? *A new solid compound that forms after a chemical reaction*
5) If a reaction causes the solution to go from colored to clear, does it count as a color change? *Yes*
6) In all of the reactions in this lesson for which a gas is given off, what is the gas? *CO2*

2. Use these fun facts during the lesson:

- Chemical changes constantly occur in living organisms.
- The human body is made up of proteins that help catalyze (speed up) complex chemical reactions.

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

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

For Part III. Determining If a Chemical Change Has Occurred

34 safety goggles for students and VSVS members
16 24-well culture plates with lids
16 plastic plates
16 Instruction sheets
32 observation sheets
15 sets of dropper bottles of each:
1.0 M HCl hydrochloric acid
1.0 M Na_2CO_3 sodium carbonate
0.5 M $NaHCO_3$ sodium bicarbonate
0.1 M $Cu(NO_3)_2$ copper (II) nitrate
0.1 M $Fe(NO_3)_3$. iron (III) nitrate
0.1 M KSCN potassium thiocyanate
Demonstration Bag A – 2 oz bottle of 0.1 M $CaCl_2$, 2 oz bottle of 1.0 M Na_2CO_3, 2 10 oz clear cups
4 jars containing the products, with precipitate in bottom
Demonstration Bag B – 2 oz bottle of 0.05 M $Na_2S_2O_3$, 2 oz bottle of 0.01 M I_2 , 2 10 oz clear cups
Demonstration Bag C - 2 oz bottle of 1.0 M HCl, jar of Na_2CO_3, 1 teaspoon, and 1 10 oz clear cu

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I. Introduction

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

Note: Do not give students the vocabulary "Law of Conservation of Mass" until they specifically make note of the phenomena, bring up the term themselves, or you've reached the discussion portion at the end of the lesson.

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

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

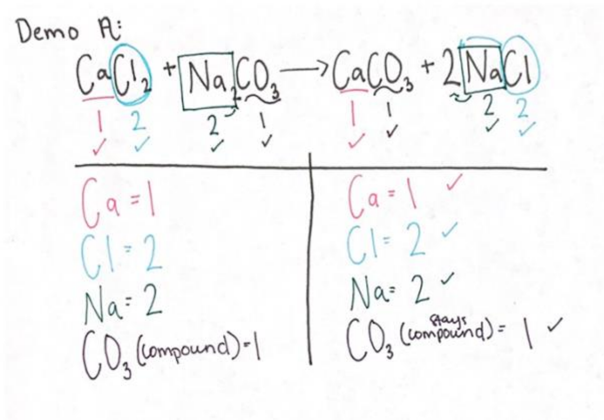
Ask students: How can you tell when a chemical change has occurred? *Some answers may include: a gas given off, color change, precipitation, explosion, burning, etc.*

Note: Wear safety goggles through ALL demonstrations!

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

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

Walk students through the equation for this demo (below). Have them follow along and mark or highlight the equation and count the number of atoms on each side as you do it on the board. (Here, we chose to use color and different style markings; you are free to choose the method that works best in your classroom as long as it is clear to students.) Be sure to explain the numbers/subscripts (marked here with arrows).



You should mark each element or compound separately and count the quantity on the left side before moving to compare it against what is present on the right side. Stress that this represents the mixing of the solutions you *just* showed them!

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

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

Walk students through the equation for this demo (below). Have them follow along and mark or highlight the equation and count the number of atoms on each side as you do it on the board. (Here we chose to use color and different style markings, you are free to choose the method that works best in your classroom as long as it is clear to students.) Be sure to explain the numbers/subscripts (marked here with arrows).

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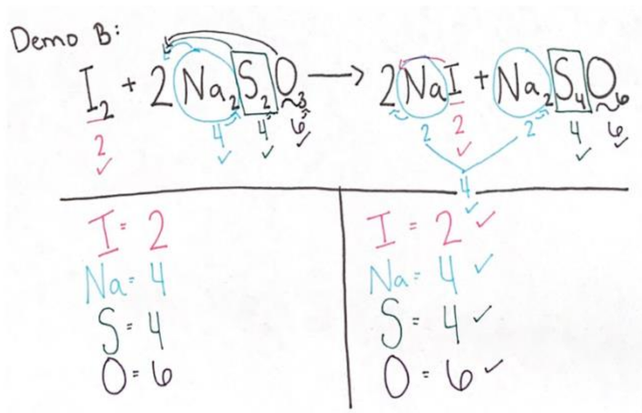
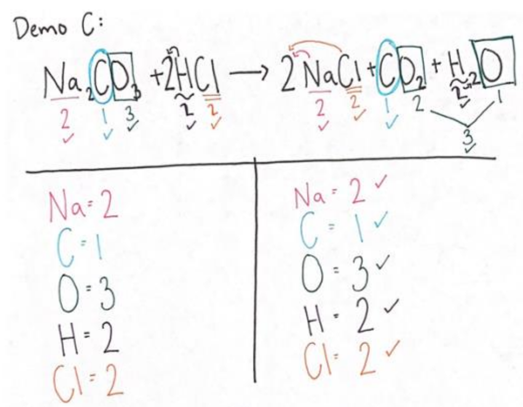


You should mark each element or compound separately and count the quantity on the left side before moving to compare it against what is present on the right side. Stress that this represents the mixing of the solutions you *just* showed them!

Demonstration C: Show students what a chemical change that produces a gas looks like.
Take the demonstration bag marked ROW C. Hold the cup up and ask students to watch very carefully what happens.
Put 1 tsp of the solid (Na_2CO_3) into the cup and empty the 2oz bottle (HCl) into it.
Ask students to describe what happens.

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

Walk students through the equation for this demo (below). Have them follow along and mark or highlight the equation and count the number of atoms on each side as you do it on the board. (Here we chose to use color and different style markings, you are free to choose the method that works best in your classroom as long as it is clear to students.) Be sure to explain the numbers/subscripts (marked here with arrows).



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You should mark each element or compound separately and count the quantity on the left side before moving to compare it against what is present on the right side. Stress that this represents the mixing of the solutions you *just* showed them! At this point, you may wish to hint that all elements and element numbers are the same on the left and right side of the equation.

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

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

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

After writing these observations on the board, share the following explanation with students.

1. A **color change** occurs when two solutions are mixed and a new color is produced (but the solutions remain transparent).
    - BUT, if the color of one solution becomes a paler shade, that change is caused by dilution from the other solution and does not qualify as a color change.
2. Bubbles or fizz indicate that a **gas is given off**.
    - BUT, make sure that students understand that the bubbles given off in a soda pop drink is NOT evidence of a chemical change. This is just excess gas that is released when the top is opened. Carbonated beverages contain carbon dioxide gas dissolved under pressure, and removing the top lowers the pressure and allows carbon dioxide bubbles to escape.
3. A **precipitate** forms when two substances react to give a new solid compound that does not dissolve in water.
    - A precipitate will MOST LIKELY look like a cloudy solution, fine grains in a solution, a swirl, or a fluffy solid. The solution will no longer be transparent due to the precipitate being suspended in the liquid (like dust).
    - BUT, make sure students understand that situation like a temperature change could cause something to fall out of solution, which might look like a precipitate but it is not.

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

4. **An energy change (temperature or light)** can be either a physical or chemical change. A chemical energy change occurs in a glow stick when chemicals mix to produces light. A physical energy change occurs when you freeze water.

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

II. Safety Concerns

- Do not give students any materials until you have covered all of this information and are ready for them to use the materials.
- Tell students they must put on safety goggles before mixing any solutions.
- Students should not directly smell any chemicals.

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- If anyone gets any of the chemicals on their skin or in their eyes, they should flush immediately with water. Although the solutions are dilute, they could still cause eye damage, especially the 1.0 M HCl.
- Emphasize to students how important it is for them to follow directions.
- Volunteers should wear goggles as much as possible to promote safety and good behavior from students.

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

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

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

Give the following instructions to the students:

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

2. Show students one of the bottles and demonstrate how to get drops out of the bottle. Dropper bottles are easy to use. Apply slow, gentle pressure. Do not remove the red cap from a bottle until it is to be used. Put the cap back on the bottle immediately after use.
   When using two solutions, put a squirt of the first solution in the correct well so that it is one-fourth full (we do not want students to spend time counting drops). Then add one squirt of the second solution. The well should now be half full.

3. Tell students they will perform the reactions for one row at a time (as VSVS members tell them to) then stop and discuss the results with the VSVS members. Tell the partners to take turns doing the

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experiments as they follow the grid on the lab sheet. Both students record their observations on the lab sheet. Students can record NR if No Reaction occurs. Otherwise, they will record color change, gas given off, or precipitate formed.

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

III. Determining If a Chemical Change Has Occurred

Learning Goals:

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

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

Note: VSVS volunteers need to monitor the students closely to be sure contamination does not occur. Ensure that students use the correct bottle. (This should be done by having VSVS volunteers move around the classroom to help student groups throughout the lesson.)

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

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

A. Chemical Reactions that Give Precipitates - Row A

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

Review:

- Equations:

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

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

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

- Pause here to ask "What did you notice was similar about these equations?" Students should note that both of these resulted in a precipitate forming. Fill this in on the chart in the board. They

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should also begin to pick up on the fact that both sides of the equation *always* have exactly the same number of each atom. Note this if they don't.

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

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

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

Review and Equations:

- Equations:

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

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

- Pause here to ask "What did you notice was similar about these two reactions?" Students should note that both of these resulted in a color change. Stress that this is one of the ways they can tell this was a chemical reaction.

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

C. Chemical Reactions that Produce a Gas - Row C

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

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

Review and Equations:

- Equations:

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

  C2: $Na_2CO_3 + 2HCl \rightarrow 2NaCl + CO_2(g) + H_2O$

- Pause here to ask "What did you notice was similar about these two reactions?" Students should note that both of these resulted in a gas being given off. They should also note that they were able to figure out the missing number on their observation sheets because the left side and the right

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side of the equation always contain the same number of atoms. Tell them that this is called the **Law of Conservation of Mass** and that in chemical reactions, no matter is ever created or destroyed, it's simply "mixed around" to make different stuff! Even in these last two experiments where it may have looked like you lost some of the solutions, nothing was actually destroyed. There was just a "loss" of carbon dioxide.

IV. Review Questions

Ask students**:**

- What is a physical change?
- What is a chemical change?
- What are the chemical changes we saw today?
- How do we know when a chemical change has occurred?

V. Clean-up

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

Lesson written by Dr. Melvin Joesten, Chemistry Department, Vanderbilt University
Pat Tellinghuisen, Program Coordinator of VSVS 1998-2018, Vanderbilt University
2019 Modifications Paige Ellenberger, Program Coordinator of VSVS 2019-present, Vanderbilt University

Your Notes:

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Chemical Reactions Observation Sheet

A1 2 $Fe(NO_3)_3$ + 3 Na_2CO_3	**A2** $Cu(NO_3)_{2.}$ + Na_2CO_3
B1 $Fe(NO_3)_{3.}$ + KSCN	**B2** $Cu(NO_3)_2$ + KSCN
C1 $NaHCO_3$ + HCl	**C2** Na_2CO_3 + 2HCl

HCl – hydrochloric acid
Na_2CO_3– sodium carbonate (baking soda)
$NaHCO_3$– sodium bicarbonate
$Cu(NO_3)_2$ – copper (II) nitrate
$Fe(NO_3)_3$– copper (II) nitrate
KSCN – potassium thiocyanate

Demo A. $CaCl_2 + Na_2CO_3 \rightarrow CaCO_3 + 2NaCl$

Demo B. $I_2 + 2Na_2S_2O_3 \rightarrow 2\ NaI + Na_2S_4O_6$

Demo C. $Na_2CO_3 + 2\ HCl \rightarrow 2\ NaCl + CO_2 + H_2O$

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

A2. $Cu(NO_3)_2 + Na_2CO_3 \rightarrow CuCO_3 + 2\ NaNO_{3\backslash}$

B1. $Fe(NO_3)_3 + KSCN \rightarrow Fe(SCN)(NO_3)_2 + KNO_3$

B2. $Cu(NO_3)_2 + KSCN \rightarrow Cu(SCN)(NO_3) + KNO_3$

C1. $NaHCO_3 + HCl \rightarrow NaCl + CO\_\_\_ + H_2O$

C2. $Na_2CO_3 + 2HCl \rightarrow \_\_\ NaCl + CO_2 + H_2O$

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Crazy Traits

Spring 2022
This lesson was adapted from CPO Crazy Traits Lesson.

Goal: To understand some basic principles of heredity by building creatures determined by flipping a coin for different traits.
Introduces/reinforces TASS: 7.LS3.3 Predict the probability of individual dominant and recessive alleles to be transmitted from each parent to offspring during sexual reproduction and represent the phenotypic and genotypic patterns using ratios.

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 20^{th} 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**

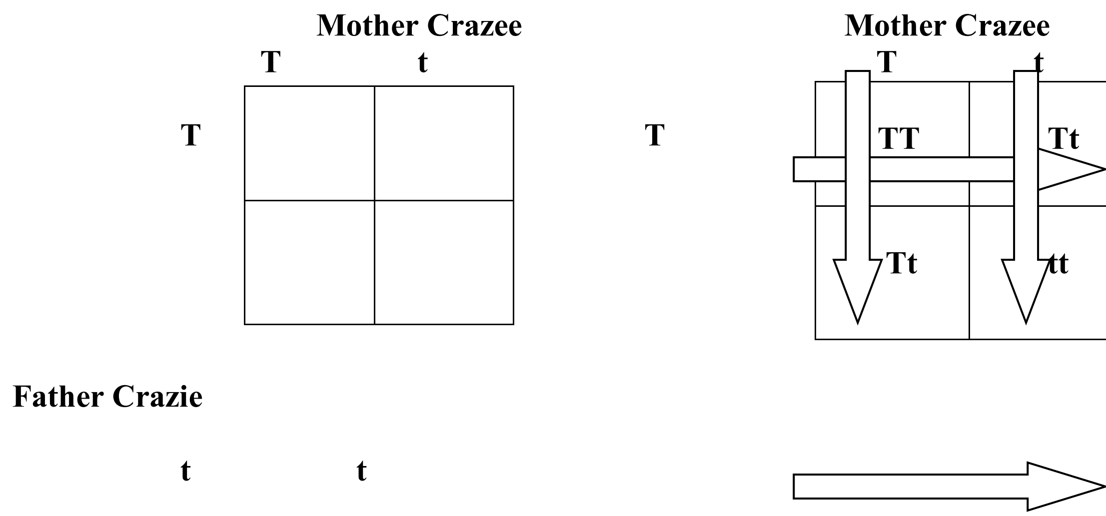
1. Show the students the mother Crazee and father Crazie.
    - Tell them that both parents have the same genotype, Tt for all traits.
        - **Usually, the capital T represents the dominant allele, and the lowercase t represents the recessive allele**
    - Each group is going to create an offspring 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,

Your Notes:

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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.

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.

Your Notes:

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- 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.
  - 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).

Yo

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

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:

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 2022

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.

Introduces/reinforces TASS: 7.PS1.6 Create and interpret models of substances whose atoms represent the states of matter with respect to temperature and pressure

VSVSer 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 shows the effect of acidic water on seashells and corals.

_____ **V. Review**

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

1. 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. *Answer in 1b. part 2*

Your Notes

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2) Think of several basic "uses" of carbon dioxide in every-day life. (Hint: plants, carbonated drinks, air, Halloween, fire)
3) What properties of dry ice distinguish it from regular ice? *Answer in Section II*
4) Why is rainwater **slightly** acidic? *Answer in Section IV*
5) Why does dry ice bubble in water? *The water is warm enough to cause the dry ice to sublime and produce carbon dioxide gas bubbles*
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? *Answer in III and IV*
7) How is **acid rain** different from rainwater? What causes **acid rain**? *Answer in Section IV*

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:

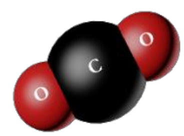
Part 1: Distribute the Instruction sheets (containing thermometer diagram), plus Handout containing Universal Indicator chart, Greenhouse effect diagram, cave formation diagram to pairs of students. Distribute an observation sheet to each student.

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
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 $1/3^{rd}$ fill 16 10 oz cups with "ocean" water for Part III
> One VSVS volunteer needs to $1/3^{rd}$ 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.

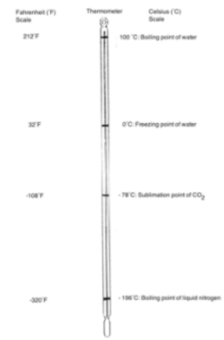
> For VSVS information only: Then the carbon dioxide-rich gas is pressurized and refrigerated until it liquefies. Next, the pressure is reduced. When this occurs some liquid carbon dioxide vaporizes, causing a rapid lowering of temperature of the remaining liquid. As a result, the extreme cold causes 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

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.
- A liquid changes to a gas by **vaporization** (boiling).

Your Notes

- 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 observe them periodically to see what happens over time.

Your Notes

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.

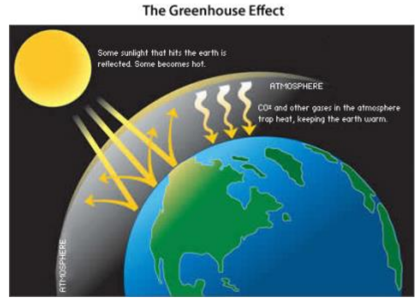
Remind students that all these changes of state are physical changes, not chemical changes.

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.

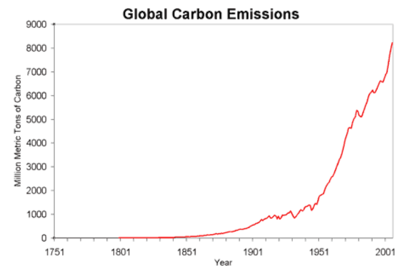
The Greenhouse Effect



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	$\rightarrow$	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

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	$\rightarrow$	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

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.

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Your Notes

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 2022

GOAL: To introduce the students to the study of genetics.
Introduces/reinforces TASS: 7.LS3.3 Predict the probability of individual dominant and recessive alleles to be transmitted from each parent to offspring during sexual reproduction and represent the phenotypic and genotypic patterns using ratios.

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. *Answer in Section II*
2. a. Which blood types can Type A donate to and receive transfusions from? Why?
   b. Type B? c. Type AB? d. Type O? *Answer in the end of Section II*
3. Why is blood typing so important? What would happen if someone received a transfusion of an incompatible blood type? *Answer below and in section III*
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:

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.

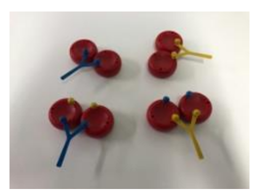
Scenario: Mrs. Sanderson developed a rare kidney disease that causes the kidney to lose function over time. She had been doing well for the past few years, but it seems that her kidney is starting to decline rapidly. Her doctors suggest that the best way for her to live a long life is for her to receive 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.

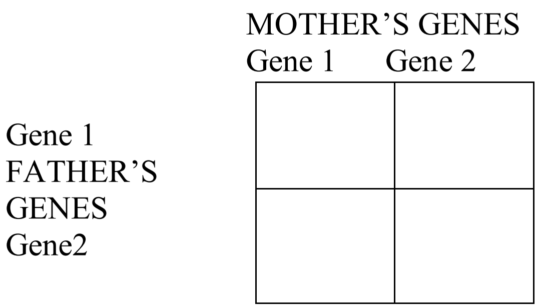


Figure 1. Punnett Square

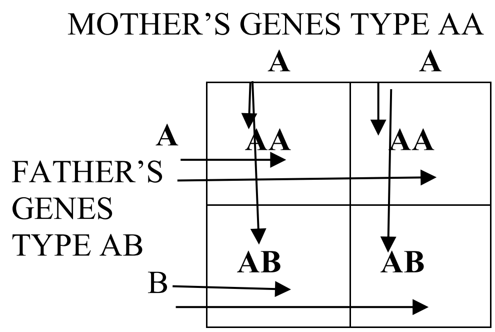


Figure 2. Filling in the Punnett Square

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**

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Recipe for One Liter of Blood Typing Solutions

A type (Mrs. Sanderson): **60 g anhydrous $CaCl_2$ per liter of distilled water plus V drops of food coloring**

B type (Mr. Sanderson): **120 g hydrated $AlCl_3$ ($AlCl_3 \cdot 6\ H_2O$) per liter of distilled water plus X drops of food coloring**

AB type (Jill): **120 g hydrated $AlCl_3$ ($AlCl_3 \cdot 6\ H_2O$) plus 60 g anhydrous $CaCl_2$ per liter of distilled water + Z drops red food coloring**

O type (Jack): **1 liter of distilled water +Y drops red food coloring**

Anti A: **0.1 M sodium oxalate ($Na_2C_2O_4$) - 13.4 g per liter of distilled water plus 10 drops of blue food coloring**

Anti B: **1 liter of household ammonia plus 10 drops of yellow food coloring**

Always test new solutions to make sure the correct results are obtained.

A plus anti-A gives a precipitate
A plus anti-B – no change
B plus anti-A – no change
B plus anti-B – precipitate
AB plus either anti-A or anti-B gives a precipitate
No change is observed for O type with either anti-A or anti-B