VOLUNTEER INFORMATION

Team Member Contact Information

Name: ___________________________________ Phone Number: __________________________
Name: ___________________________________ Phone Number: __________________________
Name: ___________________________________ Phone Number: __________________________
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Name: ___________________________________ Phone Number: __________________________
Name: ___________________________________ Phone Number: __________________________

Teacher/School Contact Information

School Name: ___________________________________ Time in Classroom: _______________________
Teacher’s Name: ___________________________________ Phone Number: __________________________

VSVS INFORMATION

VSVS Director: Pat Tellinghuisen 615-343-4379 (W), 615-297-5809 (H)
patricia.c.tellinghuisen@vanderbilt.edu

VSVS Office: Stevenson Center 5234

Co-Presidents: Helen Zhou helen.zhou@vanderbilt.edu
Sparsh Gupta sparsh.gupta@vanderbilt.edu
Secretary: Evan Mercer evan.t.mercer@vanderbilt.edu


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

Picking up the Kit:
• Kits are picked up and dropped off in the VSVS Lab, Stevenson Center 5234.
• The VSVS Lab is open 8:30am – 4:00pm (earlier if you need dry ice or liquid N2).
• Assign at least one member of your team to pick up the kit each week.
• Kits should be picked up at least 30 minutes before your classroom time.
• If you are scheduled to teach at 8am, pick up the kit the day before or make arrangements to meet at the lab at 7:30am
• There are two 20 minute parking spots in the loading dock behind Stevenson Center. Please do not use the handicap or Medical Dean’s spaces – you will get a ticket.

While you’re there – Just relax and have fun!
SEPTEMBER

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Team Training (Lessons 2-4)

TEAM LEADER TRAINING

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CLASSROOM ETIQUETTE

Follow Metro Schools’ Dress Code!
http://www.mnps.org/policies-and-procedures/2016/7/19/sp-6114-dress-code-personal-appearance?rq=standard%20attire

- No miniskirts, shorts, tights, or tank tops.
- Tuck in shirts if you can.
- Please dress appropriately.
But what do I do in a classroom?

The key to controlling a classroom is good preparation. Kids act out when they are not engaged, so you and your team need to engage the entire classroom of students in order to promote positive behavior. **Remember, the goal is to excite kids about science and college, not to teach them the science standard backwards and forwards.** There are a few steps you can take to engage the entire classroom.

1. **Prepare your class.** There’s no reason to leave the students in suspense as to what is coming. Open each lesson with a two sentence outline of the day. “Today we will be talking about comets. We will discuss how comets form around the sun and the orbits they take, and then we will build our own comets here in the classroom.”

2. **Plan ahead.** Know your lesson, your transitions, and your questions. If you need something written on the board, write it while another team member is speaking. If you need materials from the kit, prepare them while another team member is leading an activity. If you don’t leave gaps in the activity, kids won’t have time to act out.

3. **Ask questions often and well.** Leave 7 seconds after asking the questions before calling on a student to answer. Pick different kids to ask and answer questions, not just the student whose hand goes up first. Know your questions (and potential student answers) before you ask them. When students give correct answers, tell them and reinforce their engagement with the lesson.

4. **Be flexible.** We’re there to have fun with science. If something is going wrong with the experiment kit, or if the students are responding incredibly well to one aspect of the lesson and terribly to another, it is okay to adapt. This manual is a resource, not a bible. With that said, prepare yourself for these lessons. You can’t be flexible unless you know the original lesson well enough to properly modify it on the spot.

DIRECTIONS TO SCHOOLS

**H.G. HILL MIDDLE SCHOOL: 150 DAVIDSON RD**
HG Hill School will be on the right across the railroad lines.

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

**JOHN EARLY MIDDLE SCHOOL: 1000 CASS STREET**
Going down the Cass Street, the school is on the right.

**J.T. MOORE MIDDLE SCHOOL: 4425 GRANNY WHITE PIKE**
From Lone Oak, the parking lot is on the right, and the entrance into the school faces Lone Oak, but is closer to Granny White.

**MEIGS MIDDLE SCHOOL: 417 RAMSEY STREET**
Going down Ramsey Street, Meigs is on the left.

**ROSE PARK MAGNET SCHOOL: 1025 9th AVE SOUTH**
The school is located on the left and the parking is opposite the school, or behind it (preferred).

**WEST END MIDDLE SCHOOL: 3529 WEST END AVE**
Parking is beside the soccer field, or anywhere you can find a place. Enter through the side door.

**MARGARET ALLEN MIDDLE SCHOOL: 500 SPENCE LANE**

**EAST NASHVILLE MAGNET SCHOOL: 2000 GREENWOOD STREET**
The school also has the name Bailey Junior High etched in stone!
VANDERBILT STUDENT VOLUNTEERS FOR SCIENCE
http://studentorgs.vanderbilt.edu/vsvs
Ultraviolet Light
Mini Lesson for Fall 2017

Goal: To study the properties of ultraviolet light (UV light). To test the ability of various substances to protect skin against UV light.

Fits TN standards
GLE: 0707.11.6 and 0707.7.9 Investigate the types and fundamental properties of waves
GLE: 0707.1.6 Describe the function of different organ systems.

VSVSer Lesson Outline:

I. Introduction
   A. The Integumentary System
      Discuss the different parts of skin. Refer to the Ein-o skin model.
   B. Electromagnetic Spectrum
      Briefly explain electromagnetic radiation and point out the different types - X rays, UV, visible light, IR, and radio waves. Mention that the difference in energy is because of their differences in wavelength.
   C. What is Ultraviolet light?
      Show students where UV light occurs in the electromagnetic spectrum. Explain that there are 3 kinds of UV light, depending on the wavelength (UVA, UVB, UVC).

II. Demonstrations
   A. How Is UV Light Useful?
      Discuss how UV lights can be used. Examples are to kill bacteria, attract bugs, detect forgeries, detect bodily fluids in forensic work.
   B. How Can UV light Be Detected?
      Some chemicals absorb UV light and then re-emit the energy as light that we can see (visible light). Fluorescent and blacklight bulbs contain mercury vapor that emits UV light when its excited electrons return to the ground state. Blacklights have a special glass bulb that absorbs most of the visible light.
   C. How is UV light dangerous?
      Ultraviolet light has more energy than visible light, and can damage living cells. Discuss UV radiation and skin.

III. Testing UV Blocking Materials.
    Show the students the necklace made from UV beads and demonstrate the UV bead sensitivity to UV light by shining the black light on the necklace. Each group will use the purple UV-sensitive beads and a black light to test a variety of items. The items tested are a control bead, SPF 45 sunscreen, SPF 8 sunscreen, sunglass lens, a piece of T-shirt.

IV. Review Results
    Ask students to look at the observation sheets while you review the results with them.

V. Making a UV-sensitive bead bracelet
    Students make a bracelet from UV-sensitive beads that they get to keep. The beads will detect UV radiation.

VI. Discuss Ozone Depletion

LOOK AT THE VIDEO BEFORE YOU GO OUT TO YOUR CLASSROOM
https://studentorg.vanderbilt.edu/vsvs/lessons/
USE THE PPT AND VIDEO TO VISUALIZE THE MATERIALS USED IN EACH SECTION.
Complete teacher/school information on first page of manual.
1. Make sure the teacher knows Pat’s home and office numbers (in front of manual).
2. Exchange/agree on lesson dates and tell the teacher the lesson order (any changes from the
given schedule need to be given to Pat in writing (email)).
3. Since this is your first visit to the class, take a few minutes to introduce yourselves. Mention you
will be coming three more times to teach them a science lesson.

1. Before the lesson:
In the car ride, read through this quiz together as a team. Make sure each team member has read
the lesson and has a fundamental understanding of the material.
1. What are the three categories of UV radiation and what are the main differences between them?
2. What are some uses for UV light?
3. What are some ways UV light can be blocked?
4. Which items protected the bead from the UV light and which did not?

2. During the Lesson:
Here are some Fun Facts for the lesson
-Did you know that other animals can see parts of the spectrum that humans can’t? A large number of
insects can actually see ultraviolet light!
-Ultraviolet light actually means “beyond light” because it is beyond the visible light that humans can see.
The word “ultra” comes from Latin, as ultra means “beyond.”
-UV rays can be used to disinfect hospital and medical equipment. The radiation it gives off kills any
living cells on the equipment. Useful for doctors and nurses!
-Bees can see UV light! They use it to see which flowers to pollinate when the UV radiation is reflected
off of the flower petals.
-UV light can be used with special powder to find fingerprints and shoe prints that help forensic scientists
solve crimes.
-Too much exposure to UV rays causes a person’s skin to wrinkle and sag faster than normal. This is why
you should wear sunblock when going outside in the sun!

Unpacking the Kit – what you will need for each section
For Part I Introduction and Part II
A. The Integumentary System
8 Skin models, 16 handouts - Electromagnetic Spectrum

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

For Part V. Making a UV-sensitive bead bracelet
32 pieces of braid for stringing beads - each one is tied off on one end with one UV bead
32 1oz cups, 1 jar beads (about 150, 5 per student)

Your Notes:
Divide students into pairs

I. Introduction

Learning Goals:
- Students use a model to identify different layers of skin
- Students identify where UV light falls on the electromagnetic spectrum, and describe instances in which it is helpful and harmful.

One VSVS team member should write the following vocabulary words on the board while the others are giving each student an Electromagnetic Spectrum handout:

*integumentary system, electromagnetic spectrum, visible light, ultraviolet light, SPF, ozone fluorescence, phosphorescence*

B. The Integumentary System

Ask students if they know what the integumentary system is?

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

The skin is the body's largest organ.

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

Ask students to give some important functions of skin.

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

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

Point out the following layers in the model:

- **The epidermis:**
  - Forms the protective, waterproof layer of the skin.
  - Makes new cells after old ones flake off.
  - Makes melanin, which is what gives skin its color. It also protects the skin from ultraviolet (UV) ray damage from the sun by absorbing and scattering the energy. People with more melanin have darker skin and better protection from UV light. People with lighter skin (less melanin) are more vulnerable to damage from UV light.

- **The dermis:**
  - Contains sweat glands which help regulate body temperature
  - Nerve fibers which help you feel things around you
  - Hair follicles and blood vessels.

Fun Facts about skin:

Your body has about 19 million skin cells!
Your skin loses about 30,000 to 40,000 old skin cells a day. But don’t worry! Your skin keeps making cells. New skin cells last for about a month before they fall off.

On 1 square inch of skin, we have 650 sweat glands!
Skin cells change shape. They start fat and square, but as they move to the top of the epidermis, they get flatter until they finally flake off!
All the dead skin cells are on top! You have about 18-23 thin layers of dead skin cells!

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

![THE ELECTROMAGNETIC SPECTRUM](http://www.lbl.gov/MicroWorlds/ALSTool/EMSpec/EMSpec2.html)

- **Tell students to look at the Visible Light/UV Light diagram (below) and point out:**
  - Visible light has wavelengths ranging from 400 to 700 nanometers (1nm = 1 X 10-9 m).
  - These wavelengths are a small section of the full **electromagnetic** spectrum.
- Draw a wave on the board and show the students how a wavelength is measured.

![Visible Light/UV](http://www.lbl.gov/MicroWorlds/ALSTool/EMSpec/EMSpec2.html)

C. What is UV light?
- UV stands for Ultraviolet, a portion of the light spectrum that is beyond the violet light that we can see with our eyes.
  - Humans cannot see UV light.
  - UV waves have shorter wavelengths and higher energy than visible light.
Ultraviolet light is produced by the sun. What happens when it reaches the earth’s atmosphere? Most UV radiation is absorbed by the atmosphere or reflected back into space. This is the ozone layer, which we will discuss later on.

II. Activities and Demonstrations

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

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

For VSVS Information: Black lights work in the same way that fluorescent lights work. Both bulbs contain mercury vapor inside the bulb. When the bulb is electrified, electrons of the mercury atoms are excited and when they return to the ground state, UV light is emitted. In fluorescent bulbs, the UV light is absorbed by the white coating (the phosphor) and reemitted as white light. In black lights, a different phosphor is used to produce the UV light, as well as a special glass for the bulb which blocks almost all of the visible light.

B. Since we cannot see ultraviolet light, how can it be detected?
- Show the students a small “black light” and turn it on.
  - Explain that the purple glow is light from the visible, not the ultraviolet part of the EM spectrum.
  - A black light emits UV radiation in the 300-400nm range plus some visible light.

C. How is UV light dangerous?
Ultraviolet light has more energy than visible light, and can damage living cells. Skin cancer is the most common type of cancer in the US. It is estimated that 90% of non-melanoma skin cancers are associated with exposure to UV radiation from the sun. Like visible light, Ultraviolet light has many different wavelengths. There are three categories of UV radiation: UVA, UVB, and UVC.

Your Notes:
UVA rays can age us and UVB rays can burn us. Overexposure to either can damage the skin. **Refer back to the skin model to show how deep the UV rays can penetrate.**

UVA: (at 400-315nm) is the closest to the visible light. **UVA rays** penetrate deep into the dermis, the skin’s thickest layer. Unprotected exposure can lead to premature skin aging and suppression of the immune system. And when your skin’s defenses are down, you’re at risk for skin cancer.

However, recent studies show that UVA damages skin cells in the basal layer of the epidermis, where most skin cancers occur. UVA contributes to and may even initiate the development of skin cancers.

UVB: (315-290nm) is mostly absorbed by the ozone layer in the atmosphere. The amount of UVB light that reaches the ground depends on where the sun is in the sky, the amount of ozone in the atmosphere, and the cloudiness of the sky. On a clear summer day, the maximum amount of UVB radiation occurs around midday, and so the most intense sunburn radiation occurs between the hours of 10am - 4pm.

UVB rays will usually burn the superficial layers of your skin. Sunburned skin doesn’t just feel awful, it can cause permanent damage over time.
- When UVB light damages DNA, our cells might not work correctly. Sometimes this makes the cells grow uncontrollably, a condition called cancer.
- UVB light also damages the tissue in our eyes and can cause cataracts.

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

How do you know if your skin has received too much UV light?
- It turns red and becomes tender, i.e., you get a sunburn.

We should block as much UV light from our bodies as possible. Ask students if they know ways we can block UV light. Answers should include:
- sunscreen, long sleeves and pants, wide brimmed hats, sunglasses, and staying in the shade.
- Glass in windows transmits less than 10% of sun-burning UV light.
- **AVOID TANNING BEDS – THEY USE UV LIGHT**
  - Watch for the UV Index – it is issued daily for your zip code and predicts the level of solar UV radiation and indicates the risk of overexposure on a scale from 0 (low) to 11 or more (extremely high). A special [UV Alert](#) may be issued for a particular area, if the UV Index is forecasted to be higher than normal.
  - **AVOID TANNING LOTIONS – THEY DO NOT PROTECT YOUR SKIN.**

### III. Testing UV Blocking Using UV Sensitive Beads

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

- Divide the students into pairs and give each pair one of the UV lights.
- Show the students a string of UV detecting beads. Point out that all the beads are white.
- Expose the necklace to a portable UV light, until the beads have turned color.

**Your Notes:**

______________________________________________________________________________
Explain that this color change is due to the presence of UV light. The beads contain a chemical that absorbs the UV light and reemits it as visible light.

Point out the purple beads in the necklace and tell the students that they will be using just the purple beads for this experiment because these change to a more intense color than the others.

For VSVS information only: The color change involves a dye molecule absorbing UV energy to produce a different geometric isomer of the molecule. When the UV energy is removed, the color slowly fades as the dye molecule rotates back to the more stable form. Since the color fades slowly, this is an example of phosphorescence.

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

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

Who should wear sunscreen?
- Everyone! “Although darkly pigmented persons develop skin cancer on sun-exposed sites at lower rates than lightly pigmented persons, UV exposure will still increase their risk for developing skin cancer.”

Distribute the following to each group:
  - The Ziploc bags of materials to be tested
  - 1 blacklight
  - Distribute a pair of goggles to every student, and VSVS members. (The goggles will block any UV radiation from reaching eyes.)

A. Demonstrating the procedure:
- Tell the students they will be testing several items to see how well they block UV radiation. They will be using the UV-sensitive beads and observing their color change. This is phosphorescence, since the beads absorb the UV light but continue re-emit visible light even when not exposed to UV
- Tell them they need to have a control bead to compare the effect of the protection. The control bead will be completely exposed to the UV light, whereas the other beads will have some protection.

Your Notes:
Show the students the observation sheet, the positions to place the beads and materials to be tested. Demonstrate steps 1-3 and then tell the students to do the experiment.

1. Put 3 beads in the squares on the first row of the observation sheet, and cover with the lens of a sunglass, and the piece of T-shirt. Leave one bead uncovered – this is the control bead. Tell the students they will be exposing these items to UV light and will be observing the color changes that occur.
2. Hold the UV light about 1-2 inches above the beads (make sure all beads have UV light shining on them at the same time).
3. When the control bead has turned purple, turn the UV light off and remove the lens and material. Observe and record the color of the beads.

Tell students to collect the sunglass lens and piece of T-shirt and beads and put them back into the Ziploc bag. Do this before moving on to the next experiment.

Demonstrate steps 4-7 and the have students do the experiment.

4. Place the remaining 3 beads in the squares on the 2nd row. Show the students the acetate sheets, Q-tips and the containers of SPF 45 and SPF 8 sunscreen.
5. Dip a Q-tip in the sunscreen, spread a good amount on the acetate, and immediately put on top of the bead. (Tell them this is important to prevent the sunscreen from drying out.) **Emphasize that they should try to avoid getting any sunscreen on the paper and beads, since it is difficult to wash off.**
6. Hold the UV light about 1-2 inches above the beads (make sure all beads have UV light shining on them at the same time).
7. When the control bead has turned purple, turn the UV light off and remove the lens and material. Observe and record the color of the beads.

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

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

**IV. Review**

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

**Note:** Ask the students to look at the observation sheets while you review the results with them.
- Does sunscreen really work? Yes
- Is SPF 45 better than SPF 8? It should be but maybe not noticeable
- Do sunglasses block UV? Yes
- Does clothing protect you from UV light? Yes

**Your Notes:**

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
V. Making a UV-Sensitive Bracelet

Give each student a cup of 5 UV beads and 1 piece of braid.

 Tell the students to string the beads onto the braid. After they have finished stringing the beads, they should make a bracelet by putting the untied end through the hole in the bead on the tied-off end and tying a knot.

 When they are finished, they should shine their black light on the beads. (The beads take a few minutes to develop the full color.) Notice that the beads continue to glow after the black light is removed.

 Tell the students they get to keep the bracelet and should use it to measure the amount of UV radiation on sunny days. They could keep a diary of their results - trying different times of the day and different times of the year – summer vs. winter.

VI. Discussion: Ozone Depletion

Ask the students if they know how the earth’s atmosphere is protected from too much UV radiation.

 In the upper atmosphere, ozone is a “good” gas, since it screens out dangerous UV rays. But close to ground it is a pollutant and can act as a greenhouse gas.

 Ozone is an essentially colorless gas (pale blue at high concentrations) that has a distinctively sharp and unpleasant smell.

 Ozone is naturally formed in the atmosphere when UV rays react with O₂ to make O₃.

 The amount of screening of UV radiation from ozone has decreased by about 3% over the last decade.

 An ozone hole forms over Antarctica every spring (this has happened since the late 1970s). Ozone loss in the polar regions during the winter and spring can be as great as 50-70% of what is normally present.

 Ozone losses over the Antarctica may contribute to changes in ozone over the whole globe. This decrease causes an increase in UV rays reaching the earth’s surface.

 Ozone depletion is primarily caused by chlorine contained in chlorofluoro carbons (CFC’s). The production of CFC’s is now regulated, but it will be at least 50 years before the ozone level reverts to the level present before depletion began.

Some countries announce a “time-to-burn” index (From: www.atm.ch.cam.ac.uk/tour/index.html)

Written by: Pat Tellinghuisen, Director of VSVS
Rachel Shevin, VSVS student volunteer
Dr. Mel Joesten, Emeritus Professor of Chemistry


Additional Resources Consulted: American Academy of Dermatology
http://www.cdc.gov/mmwr/preview/mmwrhtml/rr5104a1.htm

Your Notes:
UV Light and Skin Protectant Observation sheet
NAME __________________________

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

<table>
<thead>
<tr>
<th>Bead covered by sunglasses</th>
<th>CONTR OL (Un-covered)</th>
<th>Bead covered by t-shirt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bead covered by SPF 8 sunscreen</td>
<td>CONTR OL (Un-covered)</td>
<td>Bead covered by SPF 45 sunscreen</td>
</tr>
</tbody>
</table>

### Ultraviolet Light - Observation Sheet

<table>
<thead>
<tr>
<th>Experiment 1.</th>
<th>Control UV Bead</th>
<th>No color change</th>
<th>Light purple</th>
<th>Darker Purple</th>
</tr>
</thead>
<tbody>
<tr>
<td>UV bead covered with sunglass lens</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UV bead covered with T-shirt</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Experiment 2.</th>
<th>Control UV Bead</th>
<th>No color change</th>
<th>Light purple</th>
<th>Darker Purple</th>
</tr>
</thead>
<tbody>
<tr>
<td>UV bead under SPF 8 sunscreen</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UV bead under SPF 45 sunscreen</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

**Review questions:**
What SPF sunscreen should be worn when outside?
Does clothing protect your skin from UV light?
**Goal:** To understand some basic principles of heredity by building creatures determined by flipping a coin for different traits.

This lesson was adapted from CPO Crazy Traits Lesson.

Fits TN State standards: SPI 0707.4.3: Describe the relationship among genes, chromosomes and inherited traits.

**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:

<table>
<thead>
<tr>
<th></th>
<th>T</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td></td>
<td></td>
</tr>
<tr>
<td>t</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. **During the Lesson:**

   **Here are some Fun Facts for the lesson**

   - Humans have at least 30,000 genes, which are found on chromosomes (single pieces of coiled DNA).
• Humans have 23 sets of chromosomes in each cell in their body that determine traits like height and eye color as well as more complex traits like personality and likelihood of developing disease.
• If you uncoil all the DNA you have in all your cells, you could reach the moon 6000 times.
• Gregor Mendel developed his famous laws of inheritance in the 1800s, though their profound significance was not recognized until the beginning of the 20th century.

UNPACKING THE KIT - What you will need for each section
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:
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**

<table>
<thead>
<tr>
<th>Learning Goals:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Students distinguish between the terms allele genotype, and phenotype, and can describe their role in inheritance</td>
</tr>
<tr>
<td>- Students understand and use Punnett Squares as a visualization tool for predicting the likelihood that an offspring will have a particular genotype</td>
</tr>
</tbody>
</table>

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:

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
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.

![Punnett Square Diagram]

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 phenotype is the physical appearance of a genotype and genotype is the genetic code.
   b. Match the genotype for your creature with the corresponding phenotype on the key. Have students fill in the last column on their observation sheet.

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

Your Notes:

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
### Trait Genotypes and Phenotypes

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

### 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.

#### 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.

5. Have students compare their creatures with other creatures from the class.
- 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.

Your Notes:
o 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.

<table>
<thead>
<tr>
<th>Dominant</th>
<th>Recessive</th>
</tr>
</thead>
<tbody>
<tr>
<td>short legs</td>
<td>long legs</td>
</tr>
<tr>
<td>webbed feet</td>
<td>talons</td>
</tr>
<tr>
<td>long arms</td>
<td>short arms</td>
</tr>
<tr>
<td>Paws</td>
<td>claws</td>
</tr>
<tr>
<td>Unibrow</td>
<td>separate eyebrow</td>
</tr>
<tr>
<td>trumpet beak</td>
<td>crusher beak</td>
</tr>
<tr>
<td>elephant ears</td>
<td>mouse ears</td>
</tr>
<tr>
<td>long antenna</td>
<td>short antenna</td>
</tr>
<tr>
<td>knob antenna shape</td>
<td>star antenna shape</td>
</tr>
<tr>
<td>no wings</td>
<td>wings</td>
</tr>
</tbody>
</table>

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

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

**Important:** Make sure that you have all of the parts in each box **before** you leave the classroom.
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**

Your Notes:
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
<table>
<thead>
<tr>
<th>Trait</th>
<th>Genotype of mother for the trait</th>
<th>Genotype of father for the trait</th>
<th>Genotype of offspring (after tossing coins)</th>
<th>Phenotype of offspring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>XX</td>
<td>XY</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skin color</td>
<td>Tt</td>
<td>Tt</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leg</td>
<td>Tt</td>
<td>Tt</td>
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<tr>
<td>Foot</td>
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<tr>
<td>Arms</td>
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<td>Hands</td>
<td>Tt</td>
<td>Tt</td>
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<tr>
<td>Eye Color</td>
<td>Tt</td>
<td>Tt</td>
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<tr>
<td>Eyebrows</td>
<td>Tt</td>
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<tr>
<td>Beak</td>
<td>Tt</td>
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<tr>
<td>Ears</td>
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<td>Tt</td>
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</tr>
<tr>
<td>Antenna</td>
<td>Tt</td>
<td>Tt</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Antenna shape</td>
<td>Tt</td>
<td>Tt</td>
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<tr>
<td>Tail</td>
<td>Tt</td>
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<tr>
<td>Wings</td>
<td>Tt</td>
<td>Tt</td>
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</tr>
</tbody>
</table>

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

List the dominant traits below.

List the recessive traits below.

Are there any traits that are not dominant or recessive?
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.*

<table>
<thead>
<tr>
<th>Trait</th>
<th>Genotype of mother for the trait</th>
<th>Genotype of father for the trait</th>
<th>Genotype of offspring (after flipping)</th>
<th>Phenotype of offspring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>XX</td>
<td>XY</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skin color</td>
<td>Tt</td>
<td>Tt</td>
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<tr>
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<tr>
<td>Antenna shape</td>
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<tr>
<td>Tail</td>
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<tr>
<td>Wings</td>
<td>Tt</td>
<td>Tt</td>
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</tbody>
</table>
**Diffusion**

Fall 2017

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

*TN Curriculum Alignment: SPI 0707.1.5* Observe and explain how materials move through simple diffusion.

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**VSVSer Lesson Outline**

**I. Introduction**

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

**A. Modeling Semi-Permeable Membranes**

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

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

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

**II. Testing for Glucose and Starch**

**A. Glucose Test**

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

**B. Starch Test**

Students use iodine to test for starch.

**III. Diffusion of Glucose and Starch**

**A. Glucose Diffusion**

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

**B. Predicting Which Molecules Will Diffuse**

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

**C. Testing for Diffusion of Glucose**

Groups test for glucose after 10 minutes.

**D. Testing for Diffusion of Starch**

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

**IV. Review**

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

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

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

USE THE PPT AND VIDEO TO VISUALIZE THE MATERIALS USED IN EACH SECTION.
Notes on solutions used:
The glucose solution is made to be 30%. The starch solution is made from soluble starch (a “handful” of starch “peanuts” in 1 L. water plus 1 tsp cornstarch. The solution mixture inside the dialysis tubing is 80% glucose/20% starch.

1. Before the lesson:
In the car ride, read through this quiz together as a team. Make sure each team member has read the lesson and has a fundamental understanding of the material.
1. What is diffusion?
2. What is a semi-permeable membrane, and what is the relationship between molecular size and ability to diffuse through a semi-permeable membrane?
3. Which molecule(s) is/are permeable through the dialysis tubing? Which is/are impermeable?
4. Which molecule is a polymer?
5. How can the presence of glucose be detected? How can the presence of starch be detected?

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

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

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

Your Notes:
For Part IA: Introduction.
16 clear plastic containers with wire screen and seeds, 32 Observation Sheets

For Part IB: Relative Sizes of Molecules
1 dialysis tube containing glucose and starch
1 set of laminated paper models of iodine, glucose, and starch

For Part II: Testing for Glucose and Starch
For Part IIA. Glucose Test
16 Instruction Sheets, 16 plastic bags each containing 3 Glucose Test Strips (in a small bag) and 1 Glucose Test Results Chart (laminated), 16 1-oz bottles of 30% glucose, 16 1-oz cups of water, 16 tweezers

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

For Part III: Diffusion of Glucose and Starch
IIIA Diffusion: 16 pieces of dialysis tubing placed in 6-oz plastic cups, (see set-up) 16 plastic plates.

III B: Predicting Which Molecules Will Diffuse
Paper models of the molecules from IB

For Part IIIC. Testing for Diffusion of Glucose
Glucose strips and tweezers from Part IIA

Part III D. Testing for Diffusion of Starch
Remaining iodine from Part IIB

I. Introduction

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

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

A. Modeling Semi-permeable Membranes
Materials
16 16 oz. clear plastic containers with wire screen and seeds
32 Observation Sheets
- Ask students: What is a semi-permeable membrane?

Your Notes:


- Include the following information in the discussion:
  - A **semi-permeable membrane** is a membrane in a cell that allows materials to pass into and out of a cell.
  - The openings in the membrane are large enough to allow some substances to move in and out of the cell, but are small enough to keep some substances from leaving or entering the cell.

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

### B. Dialysis tubing and Relative Sizes of Molecules

**Materials:**
- 1 dialysis tube containing glucose and starch
- 1 set of laminated paper models of iodine, glucose, and starch

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

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

- Tell students to look at the diagram on the observation sheet and point out that the dialysis tubing contains starch and glucose molecules.
  - **Starch** molecules are represented by large S’s and **glucose** molecules are represented by G’s.
  - **Iodine** molecules, represented by I$_2$’s, are shown outside the dialysis tubing because they will be added to the outer solution during the experiment.
  - **Water** is H$_2$O

- Tell students that they will work in pairs for the following experiments.
II. Testing for Glucose and Starch

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

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

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

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

**A. Glucose Test**
- Ask students if they know about testing for glucose with glucose strips.
  - Diabetics use these strips to monitor their glucose levels.
- Tell the students to place the 1-oz cup of water and the 1-oz glucose bottle on the appropriate circles on the observation sheet.
  - Take the cap off of the 1-oz glucose bottle.
- Test students not to touch the glucose test strip with their fingers - use the tweezers.
- Dip one end of the test strip into the water cup. Hold the strip above the bottle to remove any excess solution.
  - Place this strip in the rectangle on the paper (below the 1 oz bottle).
- Then test the 1 oz. plastic bottle labeled glucose with another glucose test strip, following the same procedure.
  - Wait a few minutes before checking the results.
- Tell students to compare the color of glucose test strips with the Glucose Results Color Chart, and record the values from the Glucose Results Color Chart on their observation sheets.
  - **Yellow** indicates no glucose and shades of **green** indicate the presence of glucose. The darker the shade of green, the more glucose is present.
  - Test strips dipped in glucose should be dark green indicating the presence of lots of glucose.
  - Test strips dipped in water should remain yellow.
- Use these strips to verify the final test results later in the lesson.

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

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

Your Notes:

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
B. Starch Test
Distribute the following additional materials to each pair:
1 1 oz. cup to use for testing water
1 dropper bottle of iodine (in a protective plastic container)
1 1 oz container of starch suspension (shake well)

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

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

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

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

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

B. Predicting Which Molecules will Diffuse
Materials:
1 set of laminated paper models of iodine, glucose, and starch (paper models are stored in binder)

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

Your Notes:
The small rye seeds represent small molecules, such as water, iodine, or glucose that can pass through a porous membrane both ways while larger molecules cannot.

The larger bean seeds represent large molecules such as starch molecules that cannot pass through the semi-permeable membrane.

- Ask the students if they can predict which way the different molecules will move.
  - The iodine is a small molecule and can move from the water outside the tubing, to inside it.
  - The starch is a large molecule and cannot get outside the tubing.
  - The glucose is small and should be able to move from inside the tubing to the water on the outside.

- Tell students that the molecules of substances have been diffusing in the experiments set up earlier in the lesson and it is time to check on these experiments and investigate what has been happening.
- Caution students to wait for instructions before they do the experiments.

C. Testing for Diffusion of Glucose

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

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

D. Testing for Diffusion of Starch

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

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

**Note:** If a positive test occurs when the iodine is added to the water around the dialysis tubing, the tubing has a leak. If this happens, empty their cup, rinse with water, and place a newly rinsed dialysis tubing in the cup and add iodine again. (Use the extra bottle of iodine that was provided.) If all else fails, have them observe the results of another group.
Ask students to observe the solution inside the dialysis tubing and the water surrounding it for a few minutes.
  
  o If they observe a color change, they should record it on their observation sheet.
  o *Students should observe a purple/black color inside the dialysis tubing.*

Ask students what this purple/black color tells them.
  
  o The purple/black color indicates that iodine molecules have passed through the dialysis tubing and detected the presence of starch inside the dialysis tubing. Since the outside solution is not purple/black, starch molecules have not passed through the dialysis tubing into the water.

Tell students to look at the plastic container of seeds.
  
  o Ask them if this were a model of the iodine and starch experiment, which seeds represent the iodine molecules and which represent the starch molecules.
  o The large seeds are the starch molecules because they could not get out of the dialysis tubing; the small seeds are the iodine molecules because they could travel through the dialysis tubing.

Ask students to refer to the diagram on the observation sheet and use arrows to show the direction iodine molecules have moved.

### IV. Review

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

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

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

**Collect used dialysis tubing in a large ziploc bag or dispose of them at the school. Return all unused tubing.**

Pour contents of water in all cups down the drain. Return all cups to lab in plastic garbage bag. Please do not let glucose solutions leak into lesson box – that makes for a very sticky mess to clean.

**Return used 1-oz bottles of glucose and starch and all solution containers to the VSVS lab for re-use.**


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We gratefully acknowledge the assistance of Ann Orman and Kay Boone, MNPS teachers.

**Your Notes:**
Observation Sheet  Name ________________________________

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

**GLUCOSE TEST**

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

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

**STARCH TEST**

What color is the water after iodine is added?  
__________________________

What color is the starch solution after iodine is added?  
__________________________

Predict the Direction of Movement of the Molecules:
Remembering what size beans crossed the wire screen, predict which molecules will diffuse in what direction in the experiment. Draw arrows next to a starch (S), glucose (G) and iodine (I₂) molecule in the cup diagram below, to show the predicted diffusion direction.

**DIALYSIS TUBING TESTS**

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

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

Were your predictions for the movement of the molecules correct?
Observation Sheet - Answers
Name __________________________________

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

GLUCOSE TEST

What color is the glucose strip after it is dipped in water?
no color

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

STARCH TEST

What color is the water after iodine is added?
pale yellow – the color of dilute iodine

What color is the starch solution after iodine is added?
Blue/Black

Predict the Direction of Movement of the Molecules:
Remembering what size beans crossed the wire screen, predict which molecules will diffuse in what direction in the experiment. Draw arrows next to a starch (S), glucose (G) and iodine (I₂) molecule in the cup diagram below, to show the predicted diffusion direction.

DIALYSIS TUBING TESTS

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

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

Were your predictions for the movement of the molecules correct?
Inheritance and Blood Typing

Fall 2017

GOAL  To introduce the students to the study of genetics through an activity dealing with blood typing

Fits TN standards:
GLE 0507.4.1: Recognize that information is passed from parent to offspring during reproduction
GLE 0707.4.3: Explain the relationship among genes, chromosomes and inherited traits
SPI 0707.4.4: Interpret a Punnett Square to predict possible genetic combinations passed from parents to offspring during sexual reproduction

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 a model of a red blood cell and explain what an antigen is and how it relates to blood type.

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

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

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

LOOK AT THE VIDEO BEFORE YOU GO OUT TO YOUR CLASSROOM
https://studentorg.vanderbilt.edu/vsvs/lessons/
USE THE PPT AND VIDEO TO VISUALIZE THE MATERIALS USED IN EACH SECTION.
Students will work in pairs for the activity.

1. Before the lesson:
In the car ride, read through this quiz together as a team. Make sure each team member has read the lesson and has a fundamental understanding of the material.
1. Explain the differences in the antigens and antibodies among the blood types.
2. a. Which blood types can Type A donate to and receive transfusions from? Why?
   b. Type B?  c. Type AB?  d. Type O?
3. Why is blood typing so important? What would happen if someone received a transfusion of an incompatible blood type?
4. Finish this punnet to determine the possible blood types of the children from parents with AO and BO types:
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 blood marrow transplant may also do this; the patient will eventually convert to the blood 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 (empty or containing liquid with red dye)

FOR PART II RED BLOOD CELL DEMONSTRATION:
1. red Styrofoam balls, 2 pink pipe cleaners, 2 blue pipe cleaners, 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”

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.

Your Notes:
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?
Explanation: About 5 liters of blood. At this point, show the students the 1-liter bottle and tell them that their bodies contain about 5 bottles of blood.

Ask students: What is in blood? (What makes up blood?)
Explanation:
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?
Explanation:
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**
- 4 red Styrofoam balls
- 2 pink pipe cleaners – “A” antigen
- 2 blue pipe cleaners – “B” antigen

1. The red blood cell has proteins on its surface that determines what blood type a person is. These proteins are called “**antigens**.”
2. Tell students that the ball is a model for a red blood cell. The pipe cleaners are the antigens (pink is the “A” antigen, blue is the “B” antigen).
3. Tell students that you will focus on two antigens in this activity. Jab the Styrofoam ball with the pink pipe cleaner. This red blood cell now has an “A” **antigen**.
4. Take the second Styrofoam ball and jab it with the blue pipe cleaner. This red blood cell has a “B” **antigen**.
5. These blood cells are named by the type of antigen on its surface. The red blood cell with the A antigen is an **A blood cell**. The red blood cell with the B antigen is a **B blood cell**.
6. Jab the third red blood cell with both a pink and blue pipe cleaners. Ask the students what type of blood cell this is. **Answer: an AB blood cell**
7. Show the students the fourth RBC 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 as having zero (O) antigens on its surface)

8. Tell students to look at 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.

10. **Antibodies** help in removing unwanted things from the blood. Tell students that if a person’s blood cells have one type of antigen, then that person’s blood will contain antibodies to the antigen that is lacking.

   a) If a person has blood cells with the **A antigen**, that person will have antibodies against the **B antigen and any cells with that antigen**.

   b) If someone has blood cells with the **B antigen**, that person has antibodies against cells with the A antigen.

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

Tell students to look at the Table in the handout.

<table>
<thead>
<tr>
<th>ABO Blood Type</th>
<th>Contains Antigen A</th>
<th>Contains Antigen B</th>
<th>Contains Antibody anti-A</th>
<th>Contains Antibody anti-B</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>yes</td>
<td>no</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>B</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>AB</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>O</td>
<td>no</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
</tr>
</tbody>
</table>

http://anthro.palomar.edu/blood/ABO_system.htm

11. If a person has blood type A, he cannot receive Type B or Type AB blood because the Anti-B antibodies will bind to the B antigen and tell the body to destroy these cells.

12. Ask students if they can determine what types of blood a person with Type B blood can receive? **O and B**.

13. 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.**

14. 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.**

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.

Your Notes:
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

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.

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 immune cells and antibodies from attacking the donor cells.

Tell the students that they will be blood test specialists.

Remind the students that the blood samples are not really blood.
They will be testing the samples for each person by combining sera that reacts with A or B antigens on the surfaces of red blood cells.
They will be able to tell if a sample is positive for an antigen by observing whether agglutination (clumping) occurs.
  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.
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.

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 genes (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.

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

Your Notes:
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.

<table>
<thead>
<tr>
<th>Parent Alleles</th>
<th>A</th>
<th>B</th>
<th>O</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>AA (A)</td>
<td>AB (AB)</td>
<td>AO (A)</td>
</tr>
<tr>
<td>B</td>
<td>AB (AB)</td>
<td>BB (B)</td>
<td>BO (B)</td>
</tr>
<tr>
<td>O</td>
<td>AO (A)</td>
<td>BO (B)</td>
<td>OO (O)</td>
</tr>
</tbody>
</table>

http://anthro.palomar.edu/blood/ABO_system.htm

Ask 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.

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Joe Lopez, Center for Science Outreach and VSVS
Mel Joesten, Professor Emeritus, Vanderbilt University
Sarah Baumgarten, Undergraduate student, Vanderbilt University

**Answer sheet**

**Blood Typing Lab Data Sheet**

<table>
<thead>
<tr>
<th></th>
<th>Column 1</th>
<th>Column 2</th>
<th>Column 3</th>
<th>Column 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Row A</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anti-A serum</td>
<td>+ Yes</td>
<td>- No</td>
<td>+ Yes</td>
<td>- No</td>
</tr>
<tr>
<td><strong>Row B</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anti-B serum</td>
<td>- No</td>
<td>+ Yes</td>
<td>+ Yes</td>
<td>- No</td>
</tr>
<tr>
<td>Blood Type (A, B, or O)</td>
<td>A</td>
<td>B</td>
<td>AB</td>
<td>O</td>
</tr>
<tr>
<td>Possible Genotype</td>
<td>AA or AO</td>
<td>BB or BO</td>
<td>AB</td>
<td>OO</td>
</tr>
<tr>
<td></td>
<td>Column 1</td>
<td>Column 2</td>
<td>Column 3</td>
<td>Column 4</td>
</tr>
<tr>
<td>-------------------------</td>
<td>----------</td>
<td>----------</td>
<td>----------</td>
<td>----------</td>
</tr>
<tr>
<td><strong>Row A</strong> Anti-A serum</td>
<td>Mrs. Sanderson</td>
<td>Mr. Sanderson</td>
<td>Jill</td>
<td>Jack</td>
</tr>
<tr>
<td>clumping occurs = +</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>nothing happens = -</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Row B</strong> Anti-B serum</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>clumping occurs = +</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>nothing happens = -</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Blood Type (Phenotype)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(A, B, AB or O)</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Possible Genotype</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(AA, AB, BB, AO, BO, OO)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mrs. Sanderson

Mr. Sanderson

Jill

Jack

Mrs. Sanderson

Mr. Sanderson

Jill

Jack