Mission Briefing: Contents Veterinarian Path

Overview:
We hope that you and your students extend the MEDMYST adventures with the activities designed to cover related learning objectives. The activities described are intended for use both before and after students have “played” missions of MEDMYST. The files may be printed for classroom use ONLY. They consist of mini-labs that can be done with relatively little equipment or expense.

Feel free to adapt these activities to your own classroom needs. Another resource that we suggest is the National Institutes of Health (NIH) web site at http://www.nih.gov/. It contains some excellent resources and teaching materials.

If you have specific questions, please contact us.

The MEDMYST Team:
medmyst@rice.edu

Mission Briefing:
Synopsis of Animal Alert!: Veterinarian Path (for teachers) ........................................ page 3
National Science Education Content Standards Correlation ................................. page 5
National Health Education Standards Correlation ............................................. page 7
Vocabulary Terms .................................................................................................. page 8
Mission Log ........................................................................................................ page 9

Mission Debriefings:
Activity 1 Me as a Scientist ............................................................................. page 11

Students will demonstrate their understanding of the scientific inquiry process by following a guided experiment. They will grow bacterial colonies and use a disinfectant of their choice to compare to the school’s disinfectant in an attempt to test how these variables affect bacterial growth.

Activity 2 Design It ............................................................................................ page 22

Students will use the help of a brainstorming method to guide them in the scientific method as they design and carry out their own bacterial experiment.
Mission Briefing: Mission Synopsis

This synopsis is provided as an overview for TEACHERS. We advise teachers NOT to hand this out to the students prior to playing the adventure since much of the suspense will be eliminated.

The web adventure begins with the player choosing one of three expert paths to play. Once the player chooses an expert path, they will begin role-playing as that expert in an infectious disease outbreak investigation.

Headquarters:
When the player chooses the veterinarian expert path, they will arrive at headquarters in Neuropolis to get orders from Alpha, leader of the Reconstructors. Alpha informs the player that there is a mysterious disease outbreak in pigs in the distant region of Yara. The veterinarian needs help discovering what is wrong with the pigs in Yara’s North Village.

North Village:
In the North Village, access to the pig pens are restricted unless wearing personal protective equipment (PPE). The vet has a temporary office located in the unrestricted area of the village where the PPE can be collected.

Vet office:
Inside the vet office the player can collect their PPE among other tools that are needed to examine pigs. The local epidemiologist, Maya Jones, who is investigating the encephalitis outbreak in humans, also contacts the player. She has learned from her investigation that the people in Yara suffering from encephalitis all had contact with pigs. To determine if the encephalitis outbreak is the result of a zoonotic pathogen, she needs to know what is affecting the sick pigs.

Pig pens:
Once the player puts on their PPE they can cross into the restricted area where the pigs pens are located. Here, the player will find the vet, Dr. Peter Ting, and receive further direction to examine the pigs. Inside the pig pens the player will observe the pigs for clinical signs, separate the healthy pigs from the sick, take blood samples from the sick pigs for microbiology lab analysis, and take the sick pigs’ temperatures. Next, a quarantine of pigs must be initiated to prevent the disease from spreading to other villages.
Mission Briefing: Mission Synopsis Continued

**Helicopter:**
The vet needs assistance initiating the quarantine of pigs. The player will use the helicopter to fly over the villages and stop trucks from transporting pigs outside of the village. The player will learn what a quarantine is, why it is necessary, and hypothesize about what they think will happen if pigs are quarantined in the North Village. After 2 weeks, the player discovers that the quarantine was ineffective and the disease has now spread to pigs in two other villages. The microbiologist, Dr. Jesse Abat, also contacts the player with the results of the microbiology analysis on the pigs’ blood samples. Dr. Abat determined that the pigs are infected with a new pathogen that has never been seen before, now named Yara virus. The virus has now spread to people in the South Village, where there are no pigs. The player must now go to the South Village to try and determine the source of the new virus.

**South Village:**
At the South Village the player collects and sends animals that could be sources of the new virus to the microbiology lab for analysis. The player also learns about the role that reservoirs, vectors, and hosts play in zoonotic disease transmission cycles. At this point, Alpha messages the player and requests for the player to report their findings. After submitting their findings to Alpha, the player is ordered to return to headquarters to wrap up the investigation with the microbiologist and the epidemiologist.

**Headquarters:**
At headquarters, the player reviews the investigation with the other two experts before determining what reservoir, vector, vehicle, and host are involved in the Yara virus transmission cycle. The player then learns how all the factors in the story came together to result in the emergence of a new virus that lead to the outbreak in pigs and people.
**Mission Briefing: Correlation with Standards**

**National Science Education Content Standards Correlation Grades: 5-8**

<table>
<thead>
<tr>
<th>Instructional Objectives “Animal Alert!” Veterinarian Path</th>
<th>Science Content Standard</th>
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</table>
| Students will apply science process skills by role-playing different careers in the “discovery to control” of a new disease. | **Standard A:** Students should develop the abilities to do scientific inquiry.  
**Standard G:** Students should develop understanding of science as a human endeavor.  
**Standard G:** Students should develop understanding of the nature of science. |
| Students will be able to describe how and why scientists collaborate in the identification, detection, and treatment of a disease. | **Standard A:** Students should develop the abilities to do scientific inquiry.  
**Standard G:** Students should develop understanding of science as a human endeavor.  
**Standard G:** Students should develop understanding of the nature of science. |
| Students will be able to recognize the role that animals play in disease transmission to humans. | **Standard F:** Students should develop understanding of personal health. |
| Students will know what clinical signs are and why they need to be observed in animals. | **Standard A:** Students should develop the abilities to do scientific inquiry.  
**Standard C:** Students should develop understanding of regulation and behavior.  
**Standard C:** Students should develop understanding of structure and function in living systems. |
## Mission Briefing: Correlation with Standards Continued

### National Science Education Content Standards Correlation Grades: 5-8

<table>
<thead>
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<th>Instructional Objectives</th>
<th>Science Content Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>“Animal Alert!” Veterinarian Path</strong></td>
<td><strong>Standard F:</strong> Students should develop understanding of personal health.</td>
</tr>
<tr>
<td>Students will understand what a quarantine is and its purpose.</td>
<td></td>
</tr>
<tr>
<td>Students will be able to identify a reservoir, vector, and host in a disease transmission cycle diagram.</td>
<td><strong>Standard F:</strong> Students should develop understanding of personal health. <strong>Standard C:</strong> Students should develop understanding of structure and function in living systems.</td>
</tr>
<tr>
<td>Students will be able to recognize the role of a veterinarian in investigating a disease outbreak.</td>
<td><strong>Standard G:</strong> Students should develop understanding of science as a human endeavor. <strong>Standard G:</strong> Students should develop understanding of the nature of science.</td>
</tr>
</tbody>
</table>
### Mission Briefing: Correlation with Standards

#### National Health Education Content Standards Correlation Grades: 6-8

<table>
<thead>
<tr>
<th>Instructional Objectives “Animal Alert!” Veterinarian Path</th>
<th>Health Content Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students will apply science process skills by role-playing different careers in the “discovery to control” of a new disease.</td>
<td><strong>Standard 1:</strong> Students will comprehend concepts related to health promotion and disease prevention to enhance health.</td>
</tr>
<tr>
<td>Students will be able to describe how and why scientists collaborate in the identification, detection, and treatment of a disease</td>
<td><strong>Standard 1:</strong> Students will comprehend concepts related to health promotion and disease prevention to enhance health.</td>
</tr>
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<td><strong>Standard 1:</strong> Students will comprehend concepts related to health promotion and disease prevention to enhance health.</td>
</tr>
<tr>
<td>Students will know what clinical signs are and why they need to be observed in animals.</td>
<td>NA</td>
</tr>
<tr>
<td>Students will understand what a quarantine is and its’ purpose.</td>
<td><strong>Standard 1:</strong> Students will comprehend concepts related to health promotion and disease prevention to enhance health.</td>
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<td><strong>Standard 1:</strong> Students will comprehend concepts related to health promotion and disease prevention to enhance health.</td>
</tr>
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</table>
Mission Briefing: Vocabulary Terms

Vocabulary terms that are fundamental to understanding the concepts included in MedMyst Animal Alert! are listed below. Some of the words will be encountered while playing this mission. They are located in the glossary of the expert menus, so you can click on them and get the definition as you play.

Veterinarian:

Clinical signs – Behaviors or characteristics that can be observed during the examination of a sick animal. They can give you an idea of what’s wrong with the animal.

Encephalitis (in-seh-fuh-LIE-tess) – brain inflammation

Epidemiology – A branch of medicine that studies how and why diseases spread.

Host – The potential victim of a pathogen.

Japanese encephalitis virus (JE virus) - A zoonotic disease that is caused by a virus and spread by mosquitoes. This disease affects the central nervous system of animals and humans.

Microbiology – The science and study of microorganisms.

Pathogen – An infectious or biological agent that causes disease or illness to its host. Examples include bacteria, viruses, prions, protozoa, fungi, and helminthes (multicellular worms).

Personal protective equipment (PPE) – Clothing, gloves, or a face mask that are worn to create a barrier between you and infectious materials.

Quarantine – A forced isolation of animals or people for the purpose of preventing the spread of an infectious disease.

Reservoir (rez-er-vwar) - Where a pathogen normally lives. It is a constant source of the pathogen and is required for the pathogen to survive. Disease reservoirs can be living organisms, like birds and mice, or non-living things, like water and soil.

Vector - A carrier that takes pathogens from an infected organism to an uninfected organism. They are always living organisms, such as insects, like mosquitoes, or arachnids, like ticks.

Vehicle - A contaminated object that takes pathogens from an infected organism to an uninfected organism. Often vehicles are non-living things, like toys and clothing, or contaminated food and water.

Veterinary medicine – A branch of medicine that deals with the diagnosis and treatment of disease in animals.

Zoonosis - infectious diseases that can be spread from animals to humans.
**Mission Log: Teacher Guide**

**Veterinarian Path**

**Teacher Directions:** Ask students to fill in the answers in the answer column as they proceed through the mission.

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is encephalitis?</td>
<td>Brain inflammation</td>
</tr>
<tr>
<td>What is personal protective equipment?</td>
<td>Clothing, gloves, or a face mask that are worn to create a barrier between you and infectious materials.</td>
</tr>
<tr>
<td>What clinical signs do the sick pig have?</td>
<td>Coughing, trouble breathing, and leg spasms and weakness.</td>
</tr>
<tr>
<td>What disease does the vet suspect the pigs have?</td>
<td>Japanese Encephalitis</td>
</tr>
<tr>
<td>What is a quarantine?</td>
<td>A forced isolation of animals or people for the purpose of preventing the spread of an infectious disease.</td>
</tr>
<tr>
<td>What virus has infected the pigs?</td>
<td>Yara virus</td>
</tr>
<tr>
<td>What three things do pathogens cycle between in a disease transmission cycle?</td>
<td>Reservoirs, vectors, and hosts</td>
</tr>
<tr>
<td>A ______________ is where a pathogen normally lives. It is a constant source of a pathogen and is required for a pathogen to survive.</td>
<td>Reservoir</td>
</tr>
<tr>
<td>What is a disease vehicle?</td>
<td>A contaminated object that can transmit disease from a reservoir to a host.</td>
</tr>
<tr>
<td>______ are the reservoir, ______ are the vector, ______ are the vehicle, and ______ are the host in the Yara virus transmission cycle.</td>
<td>Fruit bats, pigs, mangoes, and people</td>
</tr>
<tr>
<td>What activity disrupted the fruit bats habitat and led to the outbreak?</td>
<td>Jungle clearing</td>
</tr>
</tbody>
</table>
Mission Log: Student Activity Sheet
Veterinarian Path  Name ___________________ Date ______ Period ___

Directions: Record your observations by finding the answer that correctly matches each question. Write down the answers as you proceed through the mission.

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Mission Debriefing: Teacher Guide

Activity 1: Me as a Scientist

This activity gives students the opportunity to observe bacterial samples while testing their response to disinfectants. The student takes on the role of a microbiologist testing disinfectants for their school district.

Background:
Bacteria are a large group of unicellular, prokaryote, microorganisms that are so small, 100 average sized bacteria could fit across the period at the end of this sentence. Bacteria have three basic shapes: spheres (cocci), rods (bacilli), and spirals (spirilla). They are found in every habitat on Earth and are in the air around us all of the time. Forty million bacteria cells can be found in a gram of soil and a million in a milliliter of fresh water; large numbers of bacteria are found on the skin and in the digestive system. Most bacteria are harmless, but some species are disease producing. Agar is a gel-like substance that is derived from seaweed. Bacteria use it as a food supply. Depending on the type of bacteria, they grow circle-shaped colonies of various colors. Bacteria can reproduce every 20 minutes in optimum conditions, so a colony that starts with one bacterium can quickly grow to be a colony that you can observe on the surface of the agar.

To show the relative size of bacteria compared to other things, see this web site for a good visual for students: http://learn.genetics.utah.edu/content/begin/cells/scale/

Learning Objective:
Students will demonstrate their understanding of the scientific inquiry process by following a guided experiment. They will grow bacterial colonies and use a disinfectant of their choice to compare to the school’s disinfectant in an attempt to test how these variables affect bacterial growth.

Materials:
For each group of 2-3:
- Disposable Petri dishes with Nutrient Agar (food). Note on preparation: Ordering disposable, plastic Petri dishes from a science supply group is fairly reasonable in cost. Dry Nutrient Agar may also be ordered and will usually last for several years if refrigerated. An easy way to mix it is to use a large 4 cup size or larger glass measuring cup with a pour spout. Disinfect it by wiping with rubbing alcohol. Then mix the quantity of agar for the amount of water that will fit in to the measuring cup. Fill only about 2/3 full. Stir halfway through cooking with a spoon cleaned with alcohol. Microwave the water/agar solution until it reaches the boiling point—watch carefully to make sure you stop before it boils over. This can happen very quickly. Note the time it took to reach the boiling point; this is helpful for subsequent batches. Then, removing one lid at a time, pour a
thin layer into each of the smaller parts of the Petri dish; put the bigger lid on immediately, and let them cool to “set” at room temperature. Most condensation will disappear as it cools. To store, flip them upside down (agar side on top) after they have set and are cooled. Refrigerate until they are used. Making additional batches is fast and easy if you kept track of the microwave time for the first batch. It is possible to order pre-poured dishes but the cost is much higher. Sometimes universities have options for obtaining pre-poured dishes, but mixing your own goes pretty quickly. You will find some agar contaminations using this method, but not enough to cause experimental problems.

- **Sterile swabs** preferred, 4 per group (Purchase these at a pharmacy, or use Q-tips if that is all you have. The sterile swabs come sealed, two per package. If using Q-tips, put them in a zip-lock and instruct students to use the end toward the bottom of the bag as the sterile end.)
- **One sandwich bag per group** to hold the wetted swabs (or swabs could be stored in the packaging in which they come).
- **Choice of disinfectants** including the school’s brand, Pine Sol, Listerine, Bleach, Lysol, Ammonia
- **Forceps** for removing circles from disinfectant and placing them on agar
- **Paper towel** for blotting
- **Color coded paper** circles, cut with a hole punch from colored paper—regular copy weight paper works better than construction paper; placing them in a Petri dish with the disinfectant works well for the set up. (Teacher will pre-assign which colors will be used for which disinfectant, but make sure the bleach is assigned to the white paper.)
- **Goggles** for use while dipping disinfectant circles
- **Clear tape** for closing dishes
- **Ruler** with mm measurements and hand lenses are optional for observations
- **Mission Debriefing: Student Activity Guide, Activity 2 Me As a Scientist** (one copy per student)

**Procedure:**

1. Divide the class into groups of two or three. Distribute a copy of the Mission Debriefing: Student Activity Guide, Activity 3, Me As a Scientist to each student. Explain an overview of the activity. Demonstrate the collection process for the Petri dish as you create the classroom control dish (see # 4 and 5 below.) For the free choice, just choose something in the room such as the phone receiver or computer keyboard. This quadrant will vary among the student groups. Label this Petri dish as “Control” on the side.

   *(Note: Ideally, each student group would be given a Petri dish to create their own control which would include collections from the same locker, finger, door knob, and free choice. If you are able, provide this for each group. This is really the only way to control ALL of the variables. Explain to students the classroom control created by the teacher will provide adequate observations, but ideally, they would each create their own control Petri dish. The lab is written this way due to the limited resources most teachers face.)*

2. As a group, complete the “circle color code” under the materials list with whichever colors you have chosen. Bleach is always assigned the white color (or write these in before photocopying).

3. Students should meet with their group members to determine which two disinfectants
they will choose to test in addition to the school’s disinfectant. **Have students complete the hypothesis statement.**

4. Each group should get a Petri dish. Using a permanent marker, have students turn their Petri dishes upside down on their desk and then draw lines to divide their Petri dishes into fourths (see student directions on the Student Activity Guide handout.) If students do not turn the dish upside down, they will be labeling the lid which can rotate and ruin their data. Label as “locker”, “finger”, “door knob”, and “free choice.” (See drawing). Put the group members’ names and class period on the side of the dish.

5. Students will collect samples from four locations using a sterile swab. Wetting the swab slightly seems to help in the collection process. To wet the swab while keeping it sterile, students will need to hold the swab under running water briefly. Dipping it in a beaker could introduce contaminants. Have students store the damp swabs in a sandwich bag or the swab packaging as they take them to the sample sites. Roll the swab across the area to be tested. Open the lid of the Petri dish slightly and briefly while rubbing the swab across the surface of the correct quadrant of the Petri dish in a zig zag pattern. Roll the swab to get the collected sample from the all parts of the swab.

6. Complete the three remaining locations following this same pattern on the Petri dish. Make sure and use a clean swab each time.

7. **On the students’ Experimental dishes only:** To introduce the disinfectants to their Petri dishes, students will use forceps and dip the colored circle into the disinfectant (teacher will have assigned which disinfectant is which color—make sure bleach has been assigned the white color! It will remove the color of whatever is dipped into it anyway). Blot the circle on the paper towel to remove excess disinfectant. Too much liquid will bleed onto other areas and cause inaccurate data. Place the circles in the area where the swab touched the agar. There will be three disinfectant circles in each of the four quadrants. (See drawing.) **Students MUST test the school brand as well as two others of their choice.**
1. Use clear tape to close the dishes. STUDENTS SHOULD BE REMINDED TO NEVER OPEN THE DISHES ONCE THEY HAVE BEEN SEALED.

2. Incubate the dishes in a warm place (room temp is okay, darkened areas work well too) placed upside down, agar surface on top—this keeps condensation from dripping on the agar and spreading the bacteria to the incorrect quadrant. Students will make observations in their data tables as indicated over several days. It works well to give the dishes a few days growth before starting to record observations. Fungus (mold) spores may get into the dish from the air during the inoculation process. They can occasionally grow rapidly and fill the plate. Fungus will appear as cotton-like, fuzzy growths unlike the distinct bacteria colonies. Guide students in proper, descriptive observation words such as tan color, smooth, shiny, irregular margins (edge pattern of a colony), raised surface; have them avoid subjective terms such as gross, creepy, pretty, or sick. Dishes maybe have odors after 4-5 days; this is a good time to make connections to bacterial levels in sweaty tennis shoes and the smell that can occur there at times.

3. It is helpful for the teacher to either create sample observation data using a student group’s dish or create an experimental dish of her own. This insures quality data for groups whose dish has a problem of some sort or whose group members are absent, etc. Using the data of a trusted student group would also be an option.

4. The lab is written so that students may complete a scientific conclusion. Part B, a letter to the school district with recommendations for disinfectants, could be done as a written assignment in either science or language arts classes or it could be completed verbally, as a class, with student groups sharing their recommendations to the school district. Although the results could be sent to the school district, in the simulation it is not necessary for the learning to be effective for the students.

5. Following the experiment, have students clean all lab countertops with a disinfectant. Check with the custodial staff or district hazmat officials to see proper disposal methods. Some schools have teachers dispose of the Petri dishes in a tied trash bag, while others will have different plans. You can always douse the Petri dishes in microbial Lysol (Wal-Mart) or weakened bleach solution to kill the growth.

This version of *Me As a Scientist* by Lynn Lauterbach, was adapted from an activity by Jim Backstrom, Erwin Middle School, Loveland, Colorado, with contributions by Karen Sinclair, Erwin Middle School.
Extension Activities:

Science: Do Activity 2: Design It! as an extension of this activity. Students design their own bacteria experiments.

Science: Research topics such as MRSA, iatrogenic infection, antibiotic overuse and the development of resistant bacteria, marketing by soap companies vs. research scientists which results in the debate regarding a need for antibacterial soaps versus overuse of antibacterial products leading to the possibility of “superbugs.”

Language Arts: Have students write a business letter to the school district explaining the results of their investigation and their recommendations regarding disinfectant effectiveness.

Standards:

National Science Education Standards, Grades 5-8

Science As Inquiry

Content Standard A
As a result of activities in grades 5-8, all students should develop
- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Life Science

Content Standard C
As a result of their activities in grades 5-8, all students should develop understanding of
- Structure and function in living systems
- Populations and ecosystems

Web sites:
http://www.actionbioscience.org/biodiversity/wassenaar.html
http://www.cellsalive.com/animabug.htm
Mission Debriefing: Student Activity Sheet

Me as a Scientist Name ________________________ Date ________ Period ____

Your school district uses a disinfectant to clean their buildings. Is this product effective in killing the bacteria that collect on surfaces around the school? In this activity, you will take on the role of a microbiologist hired by the district to test several disinfectants and make a recommendation as to the one that is most effective.

Part A: The Experiment

**Problem Question:** Which disinfectant will be the most effective in killing bacteria growth?

**Background information:**
Bacteria are a large group of unicellular, prokaryote, microorganisms that are so small, 100 average sized bacteria could fit across the period at the end of this sentence. Bacteria have three basic shapes: spheres (cocci), rods (bacilli), and spirals (spirilla). They are found in every habitat on Earth and are in the air around us all of the time. Forty million bacteria cells can be found in a gram (a nickel weighs 5 grams) of soil and one million in a milliliter (one-fifth of a teaspoon is a milliliter) of fresh water; large numbers of bacteria are found on the skin and in the digestive system. Most bacteria are harmless, but some species are disease producing. Agar is a gel-like substance that is derived from seaweed. Bacteria use it as a food supply. Depending on the type of bacteria, circle-shaped colonies of various colors will appear a few days after being introduced to the agar medium. Bacteria can reproduce every 20 minutes in optimum conditions, so a colony that starts with one bacterium can quickly grow into a colony that can be observed on the surface of the agar.

**Hypothesis:**
(complete after reading through the experimental plan)

If the school district disinfectant, __________________, and __________________, (disinfectant of your choice) (disinfectant of your choice)
are tested as to their ability to kill bacteria growth, then __________________ (your group’s prediction)
will be the most effective.

**Materials:**
For each group of 2-3:
- Disposable Petri dish with nutrient agar (food for bacteria)
- 4 Sterile swabs (or Q-tips) with sandwich bag for storage
- Choice of disinfectants: circle color code
  1. School’s brand of disinfectant ________________
  2. Pine Sol ________________
  3. Listerine ________________
4. Bleach ______ white
5. Lysol __________________
6. Ammonia ______________________________

- Petri dishes to hold circles soaked with disinfectant
- Forceps for placing disinfectant circles on agar
- Paper towel for blotting
- Color coded paper circles
- Goggles for use while dipping disinfectant circles
- Clear tape
- Ruler with mm measurements and hand lenses are optional for observations

Procedure:
1. You will work in groups of two or three. Your teacher will demonstrate the bacteria collection process by creating the classroom “Control” Petri dish. This dish will be the standard for comparison for your experimental Petri dishes which you will create.
2. Read over the experimental plan. Then, meet with your group members to determine which two disinfectants your group will choose to test in addition to the school’s disinfectant. Complete the hypothesis statement above.
3. Each group will get a Petri dish. **Turn the Petri dish upside down on your desk.** The agar will be on the top side. You will label this surface. Use a permanent marker to divide the area into four parts as shown in the drawing. Label the areas “locker,” “finger,” “door knob”, and “free choice.” Write your group members names on the side of the Petri dish. (See drawing.)

4. Collect samples from four locations using a sterile swab. Wet the swab slightly, but never touch it with your fingers. Roll the swab across the area to be tested. Open the lid of the Petri dish slightly and briefly while rubbing the swab across the surface of the correct section of the Petri dish in a zig zag pattern. Roll the swab to get the collected sample from the all parts of the swab. (See drawing.)
1. The agar is food for the bacteria, so it will grow in the areas that the swab touches.

2. Complete the three remaining locations following this same pattern on the Petri dish. Use a clean swab each time.

3. Next, you will introduce the three disinfectants to each of the four areas on your Petri dish. **Put on your goggles.** Using your forceps, dip the correct circle color that is indicated for your disinfectant choice into the disinfectant. **Remember, you must test the school brand disinfectant.** The other two are your choice. Blot the circle on the paper towel to remove excess disinfectant. Too much liquid will bleed onto other areas and cause inaccurate data. Place the circles in the area where the swab touched the agar. There will be three disinfectant circles in each of the four sections. (See drawing.)

4. Clean your lab area with disinfectant. Incubate the dishes in a warm place. You will make observations of both your experimental dish and the classroom control Petri dish for several days. These will be recorded in the data table provided. Be specific in your observations using descriptive words like tan color, shiny, irregular edges, and 8 mm colony.

5. Once your observations are completed, you will make your conclusion and communicate your recommendation to the school district.
**Results/Observations:**
Include information on the growth of the colonies AND on the effect of the disinfectant circles.

**EXPERIMENTAL PETRI DISH**

<table>
<thead>
<tr>
<th></th>
<th>Day #1</th>
<th>Day #2</th>
<th>Day #3</th>
<th>Day #4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Locker</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Finger</strong></td>
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<tr>
<td><strong>Door Knob</strong></td>
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<tr>
<td><strong>Free Choice</strong></td>
<td></td>
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</tr>
</tbody>
</table>
**Results/Observations:**
Include information on the growth of the colonies AND on the effect of the disinfectant circles

**CONTROL PETRI DISH**

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<tr>
<th></th>
<th>Day #1</th>
<th>Day #2</th>
<th>Day #3</th>
<th>Day #4</th>
</tr>
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<tr>
<td>Locker</td>
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<tr>
<td>Finger</td>
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<td>Door Knob</td>
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<tr>
<td>Free Choice</td>
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</tr>
</tbody>
</table>
**Conclusion:**
Analyze your results from your observations and write a paragraph that reports what you found. Make sure you include the following: Restate your problem question, describe your findings including some data examples, and tell if your hypothesis was supported (found to be correct) or not supported (found to not be correct). Additionally, include an error analysis (possible places where errors may have occurred that affected the data) and suggestions for further experimentation.

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

__________________________

Part B:
Communicate your recommendation to the school district regarding the best choice of a disinfectant in a business letter format.
Mission Debriefing: Teacher Guide

Activity 2: Design It

Students will use the help of a brainstorming method to guide them in the scientific method as they design and carry out their own bacterial experiment.

This experiment can be used following Activity 1: Me as a Scientist OR it can be used independently of the other lab.

Learning Objective:
Students design and carry out their own experiment using bacterial cultures as their starting point. They not only gain understanding of the nature of bacteria colonies and their response to a variable change, but also learn to apply independent and dependent variables as they develop a problem question and hypothesis for their experiment.

Background:

Background information on bacteria is found in Activity 1: Me as a Scientist.

Experimental design is part of the inquiry approach in teaching science. When students are the ones developing the inquiry activity, instead of being guided by the teacher, they truly begin to understand the process. At times, teachers avoid this because it can feel scary to let go of the “control” and have all of the students doing something different. Sometimes teachers put a lot of emphasis on the product in experimentation as in a science fair type approach. That can be quite overwhelming for students and teachers and parents. But, with this Design It approach, students develop their experimental design plan themselves. They understand it and really enjoy it! The Scientific Method Planning Form with Post-It Notes handout keeps them focused on their independent, dependent, and controlled variables which can be a source of great confusion during the experimental design process. It helps students see how they can record their observations in both data table and graphical formats. And, they learn how to write great conclusions. The guidelines that follow explain how to model the procedure page by page. At the end of this section, some ideas are shared on how to apply this method to other experimental areas. The focus is on the process. A final, formal write-up would be an option sometimes, but a well edited rough draft can still provide a good assessment of the learning process without the stress and time spent on a final draft.

This Scientific Method Planning Form with Post-It Notes handout is based on a six step scientific method of 1) Problem Question, 2) Information gathering, 3) Hypothesis, 4) Experiment, 5) Results, and 6) Conclusion (a handout of this is included for your optional use). It will work equally well with whatever method you/your school/your curriculum uses; you will just need to adjust the form accordingly.
Typically, an overhead transparency or other display mode is used by the teacher, while the students have their own packet handouts and follow along. The teacher writes on the transparency, while the students use their Post-It Notes and move them along throughout the process.

**Page 29:** Give students a handout of pages 29-36. They also need 4 small “lighter” colored Post-It notes and 4 small “darker” colored Post-It notes. Have students put the “lighter” colored Post-Its on the top 4 squares of page 29. Then, the “darker” 4 Post-Its will go on the bottom 4 squares. Introduce a general topic to narrow the investigation. (This is important the first few times you use this method, plus it allows you to fit the experimentation with your unit of study. In a science fair type planning session, the topic could be totally open to any field of science study.) For this example, we will use “Exercise and the Body” for the general topic. Next, ask students to put themselves in the role of the scientist planning the experiment and think of some things they could change or vary on purpose. Items often mentioned are changing the number of exercises, changing the length of time of the exercises, changing the type of exercise, changing the gender of those doing the exercise, changing the intensity level of the exercise, changing the surface where the exercise is performed, and so forth. They should write one of those items on each of the top four Post-It Notes while the teacher fills in the overhead transparency. For the modeling situation, have the whole class write the same things. Next, ask the students to think of things the scientist could measure or observe that are different from the list above. Things they often mention are heart rate, respiratory rate, blood pressure, and calories used.

**Page 30:** On this page, the scientists will choose their variables. As a class, decide on one of the “change on purpose” Post-It Notes (length of time of exercise is a good one) and have students move that Post-It Note to page 30, where it says “Part to change.” Tell students this becomes our independent variable in our experiment—the one we choose to change on purpose. Then choose a Post-it note from the bottom of page 29 in the “measure or observe” section (heart rate is a good one). This becomes our experimental dependent variable—the one we will measure or observe (a change in). Have them transfer that Post-It Note to the correct section on page 30. Finally, return to page one and move all the remaining Post-It Notes to the bottom of page 30. Explain that these become the controlled variables, the things we make sure we “control so they don’t change. We keep them the same throughout the experiment—to the best of our ability.” This is a good point to explain to students that given enough time or equipment, we could test most of the variables chosen. As we experiment in the classroom, we will limit ourselves to the available supplies and choose experiments that work within a certain time frame. So, that would eliminate choosing “calories used” from our list. We might also want to eliminate blood pressure since most classrooms don’t have access to enough blood pressure equipment.

**Page 31:** Next, we will use our chosen variables to write our problem question. Have students transfer the independent and dependent Post-It Notes to their page 31 squares. Then fill in the appropriate words to make the sentence read “How does changing the quantity of exercise affect the heart rate?” On the bottom of page 31, help student to brainstorm some of the categories they might need to formally or informally research in order to make an informed prediction/educated guess in their hypothesis. Some
commonly mentioned categories are as follows: learn about the heart, learn how the heart responds to an increase in activity, learn about types of exercises, and so forth. Much of a scientist’s time is spent in this stage where they learn other things that are already known about their proposed problem question. That is why it is included here. In some situations, it is suitable to allow research time in the library, while in other cases the class may verbally share some things they know or read some background information in their textbook.

**Page 32:** Again, students transfer their Post-It Notes while the teacher writes them on the overhead. This step is where the hypothesis or “educated guess” is developed. The hypothesis always involves stating a prediction about what will happen to the dependent variable when the independent variable is changed on purpose. Complete the sentence at the bottom by filling in the blanks. In the example case, it could say “If the length of exercise time is increased, then the heart rate will increase.” Remind students that this step is the prediction of what the answer might be for the Step 1 Problem Step, but get as specific as possible in this step.

**Page 33:** Creating an Experiment plan is next. Begin by explaining they should list the materials they might need to complete their experiment. In this case, there isn’t much needed other than people to do the exercises and a stop watch or clock. Then demonstrate to the students how to create a step-by-step plan for their experiment. They can generate suggestions and the teacher guides the discussion to get to something similar to the following: 1) Have 5 people take their resting heart rate. Record in the data table. 2) Have the five people do jumping jacks for 30 seconds at their normal pace. Take their heart rate. Record. 3) Allow their heart rates to return to the resting heart rate level. Have them do jumping jacks for 60 seconds at their normal pace. Take their heart rate. Record. 4) Allow their heart rates to return to the resting heart rate level. Have them do jumping jacks for 90 seconds at their normal pace. Take their heart rate. Record.

**Page 34:** This step of the scientific method involves designing a data table to record the experimental information. We are rarely taught how to do this, so it is actually a good thinking skill for students. Data tables can vary a lot depending on what data needs to be collected and allowing a spot for the various trials and an average and totals column, if needed. But, if students will begin with their independent variable in the left hand column and their dependent in the right hand column, things will usually fall in place more easily. Have students transfer their Post-It Note. Again, students see that the independent and dependent variables are the thread that runs throughout the experiment. In this experiment, the data table would have “Length of time for exercises” in the left hand column with three options below: 30 seconds, 60 seconds, and 90 seconds. In the right hand column should be Person 1, Person 2, etc. This is where it can be pointed out that the more trials, the more reliable the data. It takes at least 5 trials for data to be considered reliable, although actual scientific investigations involve thousands of trials. In this case, we could consider five different people as being our trials, or even better, each of those five people could do another trial or two. It is helpful at this point to demonstrate this to students by writing trial 1, trial 2, and trial 3 under the dependent variable column. Then add a column to the right for total and average.
Page 35: This page is a continuation of the Results step. Data is usually displayed in a visual manner of some sort because it makes it easy to interpret at a glance, whereas a data table takes lots of study to figure out a trend in data. Have students transfer their independent and dependent Post-It Notes. Notice the easy way to build a title for the graph by filling in the independent and dependent graph blanks. Certainly, this is not the only way to title the graph correctly, but it helps students see the importance of keeping the focus on the interaction of the variables. A bar graph would be a good choice here. Graphing just the average of multiple trials is usually the best way to display data.

Note: A bar graph is typically used where the information is a comparison and a line graph is better when the data is connected, as in something happening over time.

Page 36: Writing a conclusion…this becomes much easier when students are guided into including the six points that follow. Scientific conclusions are not creative writing experiences. They just reflect the facts. They should be written in third person without the use of personal pronouns. That takes some getting used to, but usually just involves replacing the “I, our, we” pronouns with “the”. Conclusions can become rather “formulaic” seeming but that is okay for a scientific write-up. And, students will get very good at writing quality conclusions very quickly with just a little practice at this. Finally, have students transfer any of their Post-It Notes, even from page one, to see what things they could change to create a new problem question for further study. Many combinations are possible. In this situation, students might propose to change their variables to the “type of exercise” and see how that affects “heart rate.”

A cool way to help students understand terminology:
Because remembering independent and dependent variable definitions can be difficult for students, using the following “hand” memory device is useful. It not only helps students define the terms, but it can be used to show students where to place these variables as they create a graph of their data.

Helpful Hint on where to place variable on a graph:
Put your left hand up, thumb out. Your fingers represent the “dependent” variable and the thumb is by itself - “independent.” Remember that you put your thumb out “on purpose” which is a hint for the independent variable.
**Materials:**

For each group of 2-3:

For the presentation:
- Scientific Method Planning Form with Post-It Notes handout for each student
- 4 small Post-It notes of a lighter color AND 4 small Post-It notes of a darker color for each student

For the experiment:
- 2-3 Petri dishes per group (See Activity 1: Me As a Scientist, for methods on pouring the agar and ordering the dishes.) Students who can test their variables in several locations on one Petri dish might only need two plates, whereas students who change temperature or light conditions will need three. It is perfectly acceptable to guide students into planning experiments that don’t require excessive use of supplies.
- Various supplies depending on the problem question each group develops
- Bacterial cultures from a scientific supply house (Three types are recommended in case students choose “type of bacteria” as their variable to change; students who choose other variables should choose just one of the samples and use the SAME type of bacteria on all their culture plates. Most science supply houses will offer bacterial cultures for around $10 for enough to do a class of 30. For 120 students working in groups, it probably would be fine to just order three tubes. They seem to go much farther than indicated. Flinnsci.com and Carolina.com both have several choices. Hunt for bacteria that grow on Nutrient Agar between 25-30 ° C. Some suggested types are *Bacillus cereus*, *Serratia marcescens* (reddish pigment), and *Bacillus subtilis* but many other types will work well also. Starting with one type of bacteria will give an even growth on a Petri plate so other variables may be easily changed while keeping the bacterial growth the same.

**Procedure:**

1. Instruct students on the use of the Scientific Method Planning Form with Post-It Notes. (See Background section.) Students can save this and reuse it throughout the year on other experimental design plans, or you can have a classroom set to use.

2. Divide the students into groups of two or three. Allow them to brainstorm using the Scientific Method Planning Form with Post-It Notes handout in their group. Following the brainstorming session with a class sharing time often allows “stuck” groups to develop and idea and it allows some good instructional time for ideas that have gone off track. Some ideas students often choose as variables are as follows:
   - Changing the temperature of the incubation location (a light or a heating pad can be a source for warming)
   - Changing a disinfectant (see activity 1)
   - Changing the incubation light levels, bright, medium, dark or the type of light, fluorescent, incandescent, colored
   - Changing the type of growth medium or the agar concentration (note: certain bacteria prefer specific types of mediums, nutrient agar is a general type)
   - Introducing salt or other nutrients to the growth medium
• Changing the type of bacteria (if students choose this, they need to make sure it is the only variable they change and everything else stays the same, you will need to order three different types of bacterial cultures)

3. Each student should develop Steps 1-4 on their own notebook paper or in their journals, although they will work as a group to do this. They should plan their Problem, Information (student decides what to research), Hypothesis, and Experiment steps and turn those in for approval (See Notes: Scientific Method handout that follows). Have students hand in their pre-plan paper clipped together as a group with the best one on top. Then, the teacher only has to make corrections on the top paper and the other students can be directed to correct their rough drafts when you return the papers. The teacher can decide what supplies she will provide and inform students of those; students should bring any additional supplies a few days before the designated experiment day. The teacher will guide students in making choices that work within safety parameters, time frames given, and equipment limitations.

4. After approval, they should design a Step 5—Results, data table for use in collecting their observations. It is helpful to give them some in class research time for Step 2—Information gathering also, but this step could be assigned as homework. Ideally, they would do their research before creating their hypothesis, but that would require collecting Steps 1 and 2 first. They usually need some guidance on what to research. If time allows, this certainly would be a good way to approach this. Otherwise, it works to collect Steps 1-4 at one time.

5. On the pre-assigned day, students will be provided with Petri dishes and other supplies the teacher provides. They have supplied other items they determined they will need for their experimental plan. Remind them to label their dishes. Additional observation days will be needed for students to complete their data collection. Communicate acceptable time frames ahead of time (although all of that should be written into their experimental plan).

6. After their data collection is complete, students will complete Step 5 by creating a graph. Occasionally, the data does not fit a quantitative graph format. Another type of visual display of the results can be used in these cases, but a teacher may need to help these groups individually.

7. Step 6 will involve the students completing their conclusion.

8. A formal, final draft of the experiment may be required by the teacher or credit can be given for a corrected rough draft which still indicates student learning.

9. The following are included at the end of the teacher section for optional use.
   • Scientific Method: Notes
   • Data Table Self Check and a Graphing Self Check
   • Modified Lab Write-up Form

Extension Activities:

**Physical Science:** Other topics that lend themselves to experimental design are exploring the effects of various variables on melting points, pendulum variables, density, simple machines, convex and concave lenses, pH, and insulators.

**Earth Science:** Other topics that lend themselves to experimental design are soil comparisons and characteristics, weathering rates, solar energy interactions, effects of wind/shade on temperature, and the effect of various changes on erosion rates.

**Life Science:** Other topics that lend themselves to experimental design are plants (students grow pinto bean seeds or radish seeds or others to test variables) or invertebrates (students use several simple invertebrates such as crickets, roly polys also called pill bugs, hissing cockroaches, earthworms, etc. and they use one species or a combination of species to design their experiments).

**Technology:** Incorporate technology into experimental design by having students create a movie using a flip camera showing the various stages of their experiment. Check out [http://www.digitalwish.com/dw/digitalwish/view_lesson_plans?id=5888](http://www.digitalwish.com/dw/digitalwish/view_lesson_plans?id=5888) for more information.

Standards:

**National Science Education Standards, Grades 5-8**

**Science As Inquiry**

**Content Standard A**

As a result of activities in grades 5-8, all students should develop

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Web sites:

Site with information on growing cultures and mixing agar medium [http://www.scienceenterprises.com/growingbacteria.aspx](http://www.scienceenterprises.com/growingbacteria.aspx)

Ordering bacterial cultures and disposable Petri dishes:

Mission Debriefing: Student Activity Sheet

Design It

Investigating Scientists ________________________________

Scientific Method Planning Form

Planning Step #1: Brainstorming
Place Post It Notes in the squares below.

General Topic: __________________________________________

Things the scientist could change or vary on purpose:

Things the scientist could measure or observe (different from above):

Planning Step #2: Choosing Variables
Place Post It Notes in the squares below.

Part to change (independent variable):

Part to measure (dependent variable):

Part or parts to keep the same, where possible (controlled variables or constants):
Step 1: Problem
What is the question this experiment will try to answer? Include the independent and dependent variables in the question. For Example: What fertilizer (independent variable) will grow a bean plant to the tallest height (dependent variable)?

<table>
<thead>
<tr>
<th>Independent Variable</th>
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<table>
<thead>
<tr>
<th>Dependent Variable</th>
</tr>
</thead>
</table>

Step 2: Information
What background information will be helpful to know?
Step 3: Hypothesis

If the independent variable changes...

...then this is what will happen to the dependent variable.

Write your hypothesis below, using the boxes above as a guide.

If the _____________________________ is _____________________________,
then the _____________________________ will _____________________________.

Independent variable    describe how you will change it
Dependent variable          describe the effect of the change
Step 4: Experiment
Write out your experimental plan.

Materials List:  Safety Precautions:  Preparation:

Step-by-step instructions (like a recipe):

______________________________________________________________________
______________________________________________________________________
______________________________________________________________________
______________________________________________________________________
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______________________________________________________________________
______________________________________________________________________
Step 5: Results - Data Table
Place Post It Notes in the squares below.

Record your data in the data table below:

<table>
<thead>
<tr>
<th>When the independent variable changed:</th>
<th>This was the result (dependent variable):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Independent Variable</td>
<td>Dependent Variable</td>
</tr>
<tr>
<td></td>
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</tbody>
</table>
Step 5: Results - Graphing

**Title:** The effect of ___________________ on ____________________.

(Independent variable)        (Dependent variable)

Create a **graph** like the one above on a separate piece of graph paper.
Step 6: Conclusion - Finding Patterns

Write out your conclusion, answering these questions:

1. What was the purpose of the experiment?

2. What were the major findings? Include data examples.

3. Was the hypothesis supported by the data?

4. How did the findings compare with other research, other scientific facts you know, or other experimentation (classmates)?

5. What possible sources of error might have occurred?

6. How could the experiment be improved, or changed for further study? (See “New Design” below)

New Design: The next thing the scientist might want to know is:

The next variable to change

The next variable to measure
Notes: Scientific Method

Name _______________________________

Date ___________ Period ______

PIGS» **STEP 1: PROBLEM** - this is the question you want to answer.
   Example: What fertilizer will grow a daisy plant to the tallest height?

IN» **STEP 2: INFORMATION** - gathering research to learn background information.
   Read and record information on such topics as plant growth, fertilizers, daisy plants.

HAWAII» **STEP 3: HYPOTHESIS** - “educated guess.” Can be an “if..., then” statement.
   Be specific (state your best "guess" as to the answer to Step 1 question).

EAT» **STEP 4: EXPERIMENT** - test your hypothesis by using a step-by-step process.
   1. In your write up, explain the steps so clearly that someone could repeat your experiment from your directions.
   2. To design your experiment plan, set up two test groups.
      (Note: Some types of Experiments do not have a control group).

   **TEST GROUPS**

   **Experimental Group (s)**
   This is where you introduce the one variable you are testing.
   (Example: types of fertilizer put in the different pots you are testing.)

   **Controlled Variables**
   All other possible variables are kept the same. (Example: water amount, sun, fertilizer amount, and soil are the same for each group)

   **Control Group**
   Your standard for comparison.
   (example: no fertilizer added in pot).

RAW» **STEP 5: RESULTS** - record the facts we learned from experimenting.
   (data tables and graphs are useful)

CORN» **STEP 6: CONCLUSION**
A conclusion is a summary of the experiment. Someone who reads only the conclusion section of your report should be able to completely understand your experiment. The summary should give your results, describe what those findings mean, and suggest new questions that should be investigated. You should avoid using: "I" statements in your writing. Use phrases like "the data indicates...". A good conclusion can be written by answering six questions.
   1. What was the purpose of the experiment?
   2. What were the major findings? Include data examples.
   3. Was the hypothesis supported by the data?
   4. How did the findings compare with other research, other scientific facts you know, or other experimentation (classmates)?
   5. What possible sources of error might have occurred?
   6. How could the experiment be improved, or changed for further study?
What is a CONTROL?
The control in an experiment is the standard for comparison, in which no variable is introduced. 
Example: No fertilizer is added to one daisy planting so you can compare the fertilized pots to this unfertilized one. 
Note: Not every experiment has a control, many will.

What is a VARIABLE?
There are actually three types: dependent, independent and controlled variables. It is important to test only ONE variable at a time, and to keep all other things the same (in other words, they are controlled). (Read the step #1 question to figure out the variables.)

What is the INDEPENDENT VARIABLE?
This is the variable you change on purpose; it is also called the manipulated variable. 
Example: We changed the kind of fertilizer on purpose (graph on the x-axis).

What is the DEPENDENT VARIABLE?
This is the variable that you measure or observe a change in as a result of changing the independent variable; it is also called the responding variable. 
Example: We measure a change in height of our daisy plants (graph on the y-axis).

What is the HYPOTHESIS?
This is an educated guess about how changing the independent variable will affect the dependent variable. 
Example: If you add different types of fertilizer to daisy plants, then you will find that the Erwin Essentials Fertilizer will grow the daisy plant the highest, followed by Reed’s Richest and Clark’s Concoction.

What is a CONSTANT?
(controlled variables and constants refer to the same thing) Characteristics in an experiment that are kept unchanged in all trials. 
Example: Amount of water, sunlight, soil types, amount of fertilizer (sometimes this is called controlling your variables).

What are TRIALS?
Trials are the number of times an experiment is repeated for each level or value of the independent variable. The more trials, the more reliable the results. To be considered dependable you should do a minimum of 5 trials. 
Example: This is one trial; do at least 4 more for valid results.
### Data Table Self Check

- Does your table include columns and rows for all of the data you need to record?
- Did you put the independent variable in the first column and label it? Does it need to be labeled with a “unit” of some type (cm, seconds, etc.) to make it more understandable?
- Did you put the dependent variable in the second column and label it (cm, seconds, etc.)? (It could be the third, fourth, etc. column depending on how much data needs to be recorded).
  
  *Note: When recording your data, do not put the unit labels (cm, seconds, etc.) all the way down the column. Put it in the top box of the column which indicates the same unit for all numbers in that column.*
- Did you give your data table a title?

### Graphing Self Check

- Did you choose the correct type of graph? (Line graph for showing changes over time, temperature, etc. Bar graph is for comparing data that is “not connected.”)
- Did you choose a correct scale? (This means that you made the range of the data a size that will fill up most of your graph and not just a small part of it). Did you use increments (the spacing of numbers or categories on the “x” or “y” axis) that are accurate and evenly spaced?
- Is your graph neat and accurate? Are all the points plotted correctly? Did you use colors or symbols in some way if it would help your graph to be more understandable? If the data on the “x” axis would be more understandable by using a color-coded key or a key that explains the symbols used, did you include the key (also called a legend)?
- Does your graph have a title that relates to the problem that is graphed? Is it across the top of the graph? (You can always create a title by stating the “x” axis vs. the “y” axis).
- Does the “x” axis have a clear, neat label that describes units and states the independent variable? (The independent variable is the one you decide on; you change it “on purpose”).
- Is the “y” axis clearly labeled and does it describe the dependent variable? Are the units included on it, also? (The dependent variable is the one in which you “measure or observe” some change)

### Helpful Hint on where to place variable on a graph:

Put your left hand up, thumb out. Your fingers represent the “dependent” variable and the thumb is by itself - “independent.” Remember that you put your thumb out “on purpose” which is a hint for the independent variable.
Modified Lab Write-Up: 

Name __________________________

STEP 1 Problem (Write your problem in the form of a question.)

STEP 2 (Information “gathering” -- Think of what you can research to help you learn more about some of the things with which you are experimenting. Write two good sentences)

STEP 3 Hypothesis (Predict what you think will happen. Use an “if.....then” sentence.)

STEP 4 Experiment (Write sentences that tell how to do the experiment. You may not need all of these numbers, or you may need more.)

1.

2.

3.

4.

5.

6.

7.

8.

(continued on the next page)
STEP 5 Results (This is where you will make your data table to record your results. Also, you can put a graph of your results in this step.)

STEP 6 Conclusion (This is where you tell what you learned from your experiment. You should talk about the five things listed below. Use good sentences. Do not use the words “I, me, we, you” in your write-up. Use the word “the” in those places instead.)

*(Restate the problem question.)*

*(Findings - what were the results of the experiment, give data examples.)*

*(Tell if the hypothesis “was supported” or “was not” supported by the experimental results.)*

*(Error Analysis — were there some things in your experiment that might cause the data to not be completely accurate? List those things here.)*

*(Further Studies — Tell one way that you might change something in the experiment to turn it into a new experiment to do at another time.)*
Grading Checklist for Lab Write-Up:

Step 1—Problem
• The problem is stated in the form of a question.
• The dependent and independent variables are mentioned
• This step is specific and clear with only ONE thing being tested

Step 2—Information “gathering”
• Appropriate topics are researched
• Depth of research is acceptable
• Quantity of research is acceptable

Step 3—Hypothesis
• Clearly gives the idea of what you predict will be the answer to the Step 1 Problem question. It is in the form and an “if….then...” statement.
• Both the dependent and independent variable are mentioned.

Step 4—Experiment Step
• All experiment steps and materials are clearly listed and explained. (Someone else could do this experiment from your clear directions!)

Step 5—Results
• A data table clearly shows your results. The data table is labeled. The independent variable is in the first column, followed by the dependent variable in the next column.
• A graph (or other visual display) of the data is included. The correct type is chosen. (A bar graph is used for comparisons; a line graph is used for “continuous data” like changes over time.)
• The graph is labeled correctly: Title, x-axis (label units too), y-axis (label units too). A bar graph may include a “key”.

Step 6—Conclusion
• The Step 1 Problem question is restated.
• Major findings are summarized and examples of the data are given.
• A statement about the hypothesis is made stating if it was supported or not supported?
• Possible explanations for the findings are given.
• Possible errors are explained.
• Recommendations for further experimentation are given.

Mechanics
• The neatness level is acceptable
• Complete sentences are used. The pronouns “I, me, my, we, you, and our” are NOT used.
• Spelling has been checked.
• QUALITY work is shown.