Washington Mathematics Science Technology Public Charter High School

STEM Fair Project Student Reference Guide
Science

2017 – 2018

Part 1

Student Name: ________________________________

STEM Teacher/Sponsor: ________________________

STEM Course: ________________________________

Table of Contents

Letter to Parents and Students

The members of the Washington Mathematics Science Technology Public Charter High School welcome you to the 2017 – 2018 School Year. This year promises to be an exciting year of change for the WMST STEM Team. As we aspire to become a premier producer of the next generation of scientifically minded students and innovators, we have made some changes of which you should be aware:

1. We have changed the name of the requirement from the Science Fair Project to the WMST STEM Fair Project. We did so to reflect our acknowledgment of changes in the national focus on the integration of science, technology, engineering, and mathematics.
2. While the task of completing a STEM Fair project has proven to be very daunting to most students, the STEM Team has been working diligently to ease much of the apprehension about the process. We have set out to create this guide to demystify the progression of tasks through your STEM Fair project. The function of the Reference Guide is to:

- give step-by-step instructions with examples
- allow for practice and correction
- provide a means of organization, and
- serves as a bridge of communication between parents, students, and teachers.

With that in mind, we are pleased to present you with the *Washington Mathematics Science Technology Public Charter High School STEM Fair Project Student Reference Guide.*

Sincerely,

WMST STEM Committee

Satisfaction of Requirements

There has been a long-standing policy requiring all WMST students to complete a STEM Fair Project each year that they are a student at the school. The STEM Fair Project is a graduation requirement for seniors and is the sole multi-section assignment for the Senior Science Project course in which all seniors are enrolled. This policy has not changed.

WMST has taken on several special academic programs in the last decade that include the completion of STEM – related projects as course requirements. Often, these additional project requirements coincide with WMST's STEM Fair Project requirement. Because the load may become overwhelming for students that are involved in these programs, students may complete one project that satisfies multiple program requirements. The following is a list of the most common circumstances in which a student may satisfy the STEM Fair Project requirement by completing a project in a special academic program:

1. Students can satisfy the STEM Fair Project requirement or Senior Science Project course by satisfactorily completing a project in any of the STEM fields. In fact, we wholly encourage students to explore the fields of technology, engineering, and mathematics in addition to science as options for STEM Fair projects.
2. Project Lead the Way (PLTW) seniors may complete a single project in the field of Engineering to satisfy both their Senior Science Project course and PLTW Engineering Design Project requirements.
3. Students in an International Baccalaureate Mathematics, Biology, or Technology course, regardless of being a diploma or certificate candidate, may use their Internal Assessment (IA) work from these courses to satisfy the STEM Fair Project requirement.

International Baccalaureate Diploma Program (IBDP) candidates are required, as an additional requirement for graduation, to complete an Extended Essay (EE) by the 3rd quarter of their senior year. Where in the past it was allowable to convert STEM Fair projects into the EE, this practice will no longer be allowed. EEs must be covered separately from the STEM Fair Project requirement and may be completed in any IB course offered at the school.

The WMST STEM Fair

The WMST STEM Fair is the premier event of WMST's annual STEM Week held in February. During STEM Week there are varied activities, showcases, trips, and events that focus on Science, Technology, Engineering, and Mathematics. The STEM Fair is a showcase in which our scholars get to demonstrate the integration of these fields. Students compete within categories by presenting their STEM Fair Projects to guest STEM professionals in the DC Metropolitan area. These professional consultants judge each project for originality, the application of scientific or engineering processes, the understanding of those processes, and presentation. Prizes representing varying levels of merit are awarded to all projects as deemed appropriate by the judges. Students are chosen to participate in the STEM Fair by their STEM teachers or advisors. All students who have satisfactorily met the requirements with regard to their project will be entered. Being chosen to participate is a "Big Deal". To be chosen means that your teacher not only thinks that you did an outstanding job on your project, but also that you will be able to conduct yourself in a scholarly professional manner. In some cases, student projects may be chosen to compete in the City-Wide STEM Fair.

What Rules Pertain to Projects?

1. Every student, every year that they are enrolled at WMST must complete a STEM Fair Project.
2. There are three products of the STEM Fair Project for which students will receive a cumulative total of 30% of an advisory grade. Those components are:
    a. Completion of experimental procedure verified by STEM teacher
    b. Oral/STEM Fair Presentation
    c. Research Paper (may be graded in separate submissions according to the STEM Fair Project Timeline, Table 1).
3. The STEM Fair Project products (above) constitute 100% of the Senior Science Project grade.
4. STEM Fair Projects must fall into one of the STEM categories of Science, Technology, Engineering, or Mathematics and must be carried out using the scientific method or the engineering design process.
5. All STEM Fair Projects are subject to approval by the student's STEM teacher/advisor.
6. While research is an integral part of the process, student projects must have an experimental

component. Students following the Engineering Design Process must produce a physical, functional product that is tested.

7. Models and demonstrations alone do not constitute a valid STEM Fair Project.
8. Students must follow ethical practices when choosing and executing a project. There should be no harm done to vertebrate animals including humans. All projects dealing with animals must be conducted so as to not cause extreme and/or undue stress.
9. Projects dealing with potentially harmful substances and biological agents must be approved by the Safety Review Board (SRB) and their execution must be supervised by an advisor.

When is the Project Due?

There is no single date in which the project is due. Instead, important components of the project are due at different times. It is important that students submit each component by their respective due date. Doing so allows the teacher time to give feedback in terms of correction and going forward to the next component. This also allows the student to space their work out so careful thought and appropriate time can be given to each aspect of their project. At the discretion of the teacher, each item may or may not represent a separate grade. Table 1 is a tentative timeline for the submission of important components pertaining to the STEM Fair Project and represents the mandatory sequence of items to be completed.

STEM Fair Project Timeline

Component	Due Date	Teacher Comments/Grade		
Receive STEM Fair Reference Guide	Thursday, September 21, 2017	GET STARTED!!!!!!!		
Category & Sub-Category Selection/Purpose	Friday, September 29, 2017	Revise	Move to Next Component	
Independent & Dependent Variables/Problem Statement/Hypothesis	Friday, October 6, 2017	Revise	Move to Next Component	
Experimental Design	Friday, October 13, 2017	Revise	Move to Next Component	
Research/Materials List	Thursday, October 26, 2017	Revise	Move to Next Component	
Data Collection Table (empty)	Monday, October 30, 2017	Revise	Move to Next Component	
Written Experimental Procedure	Thursday, November 9, 2017	Revise	Move to Next Component	
Experimentation/Data Collection Table (filled in)	Wednesday, December 6, 2017	Revise	Move to Next Component	
Statistical Analysis/Graphical Results	Friday, December 15, 2017	Revise	Move to Next Component	
Conclusion/Discussion	Wednesday, December 20, 2017	Revise	Move to Next Component	
APA Formatted Research Paper	Thursday, January 25, 2018	Revise	Move to Next Component	
Tri-fold Board Project Presentation	Friday, February 2, 2018	Revise	Move to Next Component	
WMST STEM Fair	Thursday, February 22, 2018	Revise	Move to Next Component	

Laboratory Safety Guidelines

Being safe during the entirety of your experimental process should be the primary consideration throughout your project. You must consider the nature of your project and the risks associated with it. You must also follow certain guidelines to maintain ethical and humane norms with regard to the treatment of animals, humans included. While different investigations pose unique risks, there are general guidelines that should be followed all of the time when in a laboratory environment. Doing so will allow for not only a safer, but a more organized, meaningful, and seamless experience.

Laboratory Attire Guidelines

1. Wear goggles, gloves, and aprons while working in the lab with hazardous materials.
2. No shorts or open-toed shoes should be worn in the lab.
3. Long hair and loose clothes should be tied back.

General Procedural Guidelines

1. Do not touch or handle any equipment or substance with which you are not fully familiar or have not been told to touch or handle.
2. Read the labels of all substances that you will use to understand how to handle them.
3. Set all laboratory equipment firmly and levelly on lab tables, away from table edges. Round glassware should never be lain down on tables, but rather placed upright inside a holder that is firmly resting on the table.
4. Food and drink are not allowed within the laboratory.
5. Maintain a clear and organized workspace, actively eliminating unnecessary clutter.

Emergency Guidelines

1. Never attempt to put out a fire or clean a spill or broken glass on your own or without supervision.
2. Know the location of the eye wash and shower stations in your laboratory setting.
3. Know the emergency evacuation route out of the building from your laboratory location.
4. Notify your instructor of any accident, injury, fire, spill, or the breaking of any equipment immediately after it happens.
5. If leaving the lab unattended, make sure that you have cleaned up your work station, turn off all equipment, and lock the door behind you.
6. Wash your hands with soap and water before you leave the lab.

Chemical Handling Guidelines

1. Assume that every chemical is hazardous.
2. Read chemical labels for the name of the chemical, the expiration date, its concentration, its flammability, and the level of danger it may potentially cause to yourself or the environment.
3. Never return over-poured chemicals back to their bottles. If you have poured an excess, attempt to share the excess with another person.
4. Work with volatile and flammable substances under a fume hood.
5. Never place a substance up to your nose to smell it. Read the bottle to determine its identity.

Topic Selection

Selection of your STEM fair project topic is your responsibility, not that of your teacher. However, before you can move forward, your topic must be approved by your teacher. Before consulting with your teacher, you should try to have a few project ideas in mind so that you can have a productive conversation when you do talk to her/him. When you approach your teacher with an idea, the more you can tell them about your proposed experiment the more likely they are to approve the project. A good way to win them over is to hand them an experimental design worksheet that is complete to the extent possible. This worksheet will help you have an intelligent conversation with your STEM teacher about the proposed project. They want to know that you have a plan. You can get these worksheets from Dr. Clarke, Ms. Hall, and Mr. Wilson.

You may feel inclined to choose an "easy" project for which you do not have to do a lot of work. Choosing a project that is not on grade level, that is inappropriate, that you got directly from the Internet or other source, or that multiple people chose will usually cause your teacher to disapprove your topic.

The best projects come from your own observations of what happens around you. You are constantly wondering "why?", "does?" and "how?" about the things you witness every day. A stellar STEM fair project usually awaits your investigation of those thoughts and simply beginning the process.

List of Topics to Consider

Below is a list of a few STEM fair projects and topics to consider. **This list does not include all possible projects and you do not have to choose any of the projects or topics listed**. It is encouraged that you devise your own project. The list should be thought of as a brainstorming aide.

Biology

1. Human sensory perception
2. Modeling the human cardiovascular system: factors that affect blood flow rate
3. Culturing bacteria
4. Introduction of foreign substances into micro-ecosystems
5. Drosophila genetics
6. Drosophila population dynamics
7. Human physiology

8. Enzyme reactions
9. Photosynthetic pigments
10. Cellular respiration
11. Transpiration in plants

Biotechnology

1. DNA fingerprinting
2. Do it yourself DNA
3. Protein fingerprinting

Earth Science

1. Erosion prevention
2. Flood Management
3. Concentration and effect of minerals and pH in soil or water samples.
4. Chemical makeup of rain in your area; test possible hazardous effects.
5. The effects of acid rain on building materials.
6. Soil permeability

Physical Science

1. Build a solar oven.
2. Potato battery.
3. Roller coaster marbles.
4. Absorption of radiant energy by different colors.
5. Build an electromagnet.
6. Make your own low power AM radio transmitter
7. Build a battery.
8. Study acoustic models and methods of noise control.
9. Experiment with the effect of storage temperatures on batteries.
10. Develop improvements in battery chargers
11. Using solar cells to recharge batteries.
12. Compare the bending strength and durability of different building materials.
13. Effects of temperature on different building materials over time.
14. Experiment with building materials that are fire-preventative.
15. Design industrial uses of magnets;

16. Test the effects of magnetic and electromagnetic fields on living organisms such as brine shrimp or flatworms.
17. Levitation and magnets
18. Effect of Different Materials on a Magnetic Field
19. Sound frequency analysis

Chemistry

1. Ice cream making by lowering the freezing point of water
2. Acid base/cabbage chemistry
3. Boyle's Law
4. Paper chromatography
5. Test the effects of the pH level of a solution on the corrosion of iron, lead and copper
6. Different methods of corrosion prevention.
7. Experiment with types, effectiveness, and the impact on nutritional value of preservatives in food.
8. Compare the properties and effects of artificial sweetener vs. sugar or other natural sweeteners.
9. Test the chemical properties and physiological impact of saturated, unsaturated, and trans fats.
10. Use indophenol to test the effect of different cooking methods on the depletion of vitamin C in food.
11. Investigate the role of enzymes and yeast in the fermentation or cheese-making process.
12. Experiment with different methods of water filtration/purification.
13. Analyze the by-products of gasoline; compare efficiency of various octane levels.
14. Reaction rate versus particle size.
15. Reaction rates versus temperature.
16. Are Enzymes in Laundry Detergents Effective Stain Removers?
17. Salt Bridge Over Electrified Waters: How Electricity Changes pH

Environmental Science

1. Hurricanes and climate;
2. Ocean acidification
3. Acid rain and aquatic life.

4. Air particles and air quality.
5. Biomes: how plants grow in different environments
6. Compare or develop methods of hydrogen production and storage for use in fuel cells.
7. Investigate methods of improving home insulation.
8. Experiment with expanded uses of solar energy.
9. Test methods for cleaning up and neutralizing the effect of oil in salt water.
10. Work with methods of processing/recycling non-biodegradable items
11. Experiment with decomposition aids.
12. Test for harmful effects of pesticides; test or develop natural/organic alternatives.
13. Which type and color of roofing material provides the most energy efficiency?
14. Water quality in my neighborhood (creaks and ponds).
15. Water pollution and clean-up.
16. Science of composting.

Engineering

1. Build a bridge with straws and straight pens; paper bridge for pennies
2. Transfer of heat by convection in a tank
3. How does a hovercraft work

Category Selection

The next page begins a list of STEM fair categories and sub-categories. It is intended that you use this list to begin the process of developing your STEM fair project. If you have identified a topic from the list above, you should do your best to match it with a category and sub-category below. Choose at least three possible category/sub-category combinations.

Directions:

1. Choose three numbered categories in which you may be interested in completing a STEM fair project.
2. Place an "X" in the boxes beside the categories you choose.
3. Check a subcategory underneath the categories you chose to indicate the area within those categories that you think best matches each of your project ideas.

Scenario Example 1

1. Biomedical & Health Sciences [X]

	Disease Diagnosis		Epidemiology		Other
	Disease Treatment		Nutrition		
	Drug Development and Testing	X	Physiology and Pathology		

12. Energy: Chemical [X]

	Alternative Fuels		Fuel Cells and Battery Development		Other
	Computational Energy Science		Microbial Fuel Cells		
X	Fossil Fuel Energy		Solar Materials		

17. Microbiology [X]

X	Antimicrobials and Antibiotics		Environmental Microbiology		Other
	Applied Microbiology		Microbial Genetics		
	Bacteriology		Virology		

Worksheet: Category/Sub-Category Selection (Due Sept. 29)

1. Animal Sciences ☐

	Animal Behavior		Ecology		Physiology
	Cellular Studies		Genetics		Systematics and Evolution
	Development		Nutrition and Growth		Other

2. Behavioral & Social Sciences ☐

	Clinical and Developmental Psychology		Sociology and Social Psychology
	Cognitive Psychology		Other
	Physiological Psychology		

3. Biochemistry ☐

	Analytical Biochemistry		Structural Biochemistry
	General Biochemistry		Other
	Medical Biochemistry		

4. Biomedical & Health Sciences ☐

	Disease Diagnosis		Epidemiology		Other
	Disease Treatment		Nutrition		
	Drug Development and Testing		Physiology and Pathology		

5. Biomedical Engineering ☐

	Biomaterials and Regenerative Medicine		Biomedical Imaging		Other
	Biomechanics		Cell and Tissue Engineering		
	Biomedical Devices		Synthetic Biology		

6. Cellular & Molecular Biology ☐

	Cell Physiology		Molecular Biology
	Genetics		Neurobiology
	Immunology		Other

7. Chemistry ☐

	Analytical Chemistry		Inorganic Chemistry		Physical Chemistry
	Computational Chemistry		Materials Chemistry		Other
	Environmental Chemistry		Organic Chemistry		

8. Computational Biology & Bioinformatics ☐

	Biomedical Engineering		Computational Evolutionary Biology		Other
	Computational Pharmacology		Computational Neuroscience		
	Computational Biomodeling		Genomics		

9. Earth & Environmental Sciences ☐

	Atmospheric Science		Geosciences
	Climate Science		Water Science
	Environmental Effects on Ecosystems		Other

10. Embedded Systems ☐

	Circuits		Networking and Data Communications		Signal Processing
	Internet of Things		Optics		Other
	Microcontrollers		Sensors		

11. Energy: Chemical

	Alternative Fuels		Fuel Cells and Battery Development		Other
	Computational Energy Science		Microbial Fuel Cells		
	Fossil Fuel Energy		Solar Materials		

12. Energy: Physical ☐

	Hydro Power		Sustainable Design		Other
	Nuclear Power		Thermal Power		
	Solar		Wind		

13. Engineering Mechanics ☐

	Aerospace & Aeronautical Engineering		Control Theory		Mechanical Engineering
	Civil Engineering		Ground Vehicle Systems		Naval Systems
	Computational Mechanics		Industrial Engineering-Processing		Other

14. Environmental Engineering ☐

	Bioremediation		Recycling and Waste Management
	Land Reclamation		Water Resources Management
	Pollution Control		Other

15. Materials Science ☐

	Biomaterials		Computation and Theory		Polymers
	Ceramic and Glasses		Elec., Optical and Magnetic Materials		Other
	Composite Materials		Nanomaterials		

16. Mathematics ☐

	Algebra		Geometry and Topology		Other
	Analysis		Number Theory		
	Combos, Graph and Game Theory		Probability and Statistics		

17. Microbiology ☐

	Antimicrobials and Antibiotics		Environmental Microbiology		Other
	Applied Microbiology		Microbial Genetics		
	Bacteriology		Virology		

18. Physics & Astronomy ☐

	Astronomy and Cosmology		Instrumentation		Optics, Lasers Masers
	Atomic, Molecular and Optical Physics		Magnetics, Electronics and Plasmas		Quantum Computation
	Biological Physics		Mechanics		Theoretical Physics
	Computational Physics and Astrophysics		Nuclear and Particle Physics		Other

19. Plant Sciences ☐

	Agronomy		Growth and Development		Other
	Ecology		Physiology		
	Genetics/Breeding		Systematics and Evolution		

20. Robotics & Intelligent Machines ☐

	Biomechanics		Machine Learning
	Cognitive Systems		Robot Kinematics
	Control Theory		Other

21. Systems Software ☐

	Algorithms		Operating Systems
	Cybersecurity		Programming Languages
	Databases		Other

22. Translational Medical Sciences ☐

	Disease Detection and Diagnosis		Drug Identification and Testing
	Disease Prevention		Pre-Clinical Studies
	Disease Treatment and Therapies		Other

Purpose

The **purpose** of the project addresses “the big picture” and begins with one or two sentences that introduce the general topic around which the project is based. If you have a personal interest in the topic, and you should, the purpose is where you would put this information. It should discuss an observation, issue, or concern surrounding your category/subcategory and should explain how your project will contribute to better understanding and/or how it can be applied to the observation, issue, or concern. This information could come directly from your prior knowledge or may be researched.

To write a good purpose, take the following steps:

1. Introduce the topic.
2. State the observation, issue, and/or concern surrounding the topic.
3. Tell how your project will contribute to better understanding or will be applied to the observation, issue, or concern.

Scenario Example 2

Purpose

Antibiotics have played a major role in our ability to fight bacterial infections and diseases. Humans take a lot of care to control the spread of bacteria, as some pose a major threat to human health. One way in which this is done is through hand sanitizer, which contains antibiotic chemicals that kill bacteria. While they do well to eliminate most bacteria when used, this fact may have a negative effect in the future.

Increased everyday use of bacteria-fighting agents such as hand sanitizer has become an increasingly concerning habit. It has been said that overuse can lead to antibiotic resistance in harmful bacteria. Stated on most of these products are the fact that it does not kill ALL bacteria; it only kills 99.9% of them. This implies that 0.1% of them survive. Those surviving bacteria have a genetic resistance to the antibiotic in the hand sanitizer which they are able to pass on to their offspring. This mechanism leads to larger bacterial populations that are resistant to antibiotics.

This project will attempt to show how improper use of hand sanitizer may increase bacterial resistance. With this project, I hope to create a greater awareness about this problem.

Breakdown of Purpose Elements

1. <u>Introduce your topic.</u>
    - "Antibiotics have played a major role in our ability to fight bacterial infections and diseases. Humans take a lot of care to control the spread of bacteria, as some pose a major threat to human health. One way in which this is done is through <u>hand sanitizer</u>, which contains antibiotic chemicals that kill bacteria. While they do well to eliminate most bacteria when used, this fact may have a negative effect in the future."
2. <u>State the observation, issue, or concern.</u>
    - "Increased everyday use of bacteria-fighting agents such as hand sanitizer has become an increasingly concerning habit. It has been said that overuse can lead to antibiotic resistance in harmful bacteria. Stated on most of these products are the fact that it does not kill ALL bacteria; it only kills 99.9% of them. This implies that 0.1% of them survive. Those surviving bacteria have a genetic resistance to the antibiotic in the hand sanitizer which they are able to pass on to their offspring. This mechanism leads to larger bacterial populations that are resistant to antibiotics."
3. <u>Tell how your project will contribute to the better understanding of, or will be applied to the observation, issue, or concern.</u>
    - "This project will attempt to show how improper use of hand sanitizer may increase bacterial resistance. With this project, I hope to create a greater awareness about this problem."

Worksheet: Writing Your Purpose (Due Sept. 29)

Directions: Use your accepted category/sub-category as a guide to find the broad concept that your project will address. To write your Purpose, answer the following prompts.

1. Introduce your topic.
2. State the observation, issue, or concern.
3. <u>Tell how your project will contribute to the better understanding of, or will be applied to the observation, issue, or concern.</u>

---

1. Introduce your topic.

____

____

____

____

____

____

____

2. State an observation, issue, or concern about your topic.

____

____

____

____

____

____

____

3. How will your project contribute to the understanding of, or be applied to the observation, issue, or concern?

____

____

____

____

Experimental Design

The experimental design is an outline of the experimental plan to collect data that will be used to answer the central question being asked, called the **problem statement**. Scientists answer this question by experimenting, modeling, simulating, and/or observing actual events in nature. They do this to gather data from measurements that will be used to answer the question posed by the problem statement. To gather usable data, the scientist must design situations in which variables or factors related to the outcome are carefully set, kept constant, and measured. These variables include the independent variable, controlled variables, and the dependent variable, respectively.

Your experimental design is a plan that defines the three categories of variables and describes how they will be set, kept constant, and measured.

Identifying the Independent Variable

The **problem statement** is the central question that guides your investigation. A good **problem statement** asks how the **independent variable** affects the **dependent variable**. Think of these variables as having a **cause-and-effect relationship**. The **independent variable** is always the **cause**. You may also think of the **independent variable** as the ONE AND ONLY factor that the experimenter will change for each **test group**. It will be set at different levels for each test group from the beginning and throughout the **experiment**. This change in the **independent variable** causes the **dependent variable** to change.

A good procedure to determine your independent variable is as follows:

1. Research your topic. During your research, identify things that have the following two properties:
    - Can be changed relatively easily by humans
    - Will cause a change in another factor
2. List all things in your research that you find to meet both of these requirements and choose only one that you will change. This will be your independent variable.
3. The other listed items will become controlled variables.

Scenario Example 3

Independent Variable

Frequency of use of hand sanitizer

Breakdown of Independent Variable Choice

1. Can be changed relatively easily by humans
   - In the *Scenario Example 2,* it is implied that the frequency with which one uses hand sanitizer CAN BE CHANGED RELATIVELY EASILY. For example, one can easily use hand sanitizer once, twice, three, four, five, six, or no times in a week.
2. Will cause a change in another factor
   - In *Scenario Example 2,* it is implied that when hand sanitizer is used too much, it CAN CAUSE A CHANGE IN ANOTHER FACTOR: the population of antibiotic resistant bacteria.

Setting Levels of the Independent Variable

The independent variable is the single factor that the experimenter will change her/himself during the experiment. The actual change is seen in the differences between the **test groups**. These differences will be how each **test group** is individually identified. Look at the following examples to understand the relationship between the **independent variable** and the **test groups**:

Notice how the Test Groups have equally spaced increments.

Example 1

Independent Variable	Test Groups
Color of Light	Red
	Orange
	Yellow
	Green
	Blue
	Indigo

Notice how the Test Groups are all different versions of the independent variable.

Example 2

Independent Variable	Test Groups
Salt Water Concentration	1 g Salt/100 mL Water
	2 g Salt /100 mL Water
	3 g Salt/100 mL Water
	4 g Salt/100 mL Water
	5 g Salt/100 mL Water
	6 g. Salt/100 mL Water

Notice how these examples contain both measurement values and units.

Exampl

Independent Variable	Test Groups
Seed Planting Depth	1 cm
	2 cm
	3 cm
	4 cm
	5 cm
	6 cm

Scenario Example 4

Test Groups

Independent Variable	Test Group 1	Test Group 2	Test Group 3	Test Group 4	Test Group 5
Hand Sanitizer Usage Frequency	1 Time/Week	2 Times/Week	3 Times/Week	4 Times/Week	5 Times/Week

Practice Setting Levels of the Independent Variable

Independent Variable	Test Group 1	Test Group 2	Test Group 3	Test Group 4	Test Group 5
Incline Angle	15°		25°		
Daily Sunlight Exposure	5 hours		11 hours		
Environmental Temperature	5°Celcius				
Volume of Water in Bottle		30 milliliters			
Relative Humidity	10%				
Average Wind Speed			15 miles/hour		25 miles/hour
Acuity of Vision				20/60	20/70
Drop Height			4 meters above surface		
Time Allowed for Reaction to Take Place	60 seconds				
Your Experiment:					

Determining the Control Group

The **control group** is a reference point that acts as a standard against which all other groups will be compared. It is the group that represents treatment in the most normal or most average way of all the settings of your **independent variable**, or no treatment at all. C**ontrols** help you understand the expected result when no special treatment is given to the factor you are changing. To determine the **control group** setting, consider the following:

1. Once you have decided upon an **independent variable**, do research to find whether there is a **normal** setting/value for this factor with regard to the experiment you are planning.
   a. If there is a **normal setting** for this factor, make that setting your **control group**.
   b. If there is no **normal setting**, proceed to step 2.
2. Give the control group a "0" setting if:
   a. If it is normal to not treat the test subject with the **independent variable**.
   b. If treatment with the **independent variable** is not known to be a vital factor required by the experiment to get meaningful measurement.
   c. If it is normal to treat the test subject with the **independent variable** but there is no recommended value, proceed to step 3.
3. Make an informed decision. Which setting (based on research) do you think will yield a specific result? Set the control group as one of the following accordingly:
   a. The value one level lower than the lowest **test group**
   b. The average or middle value of all **test groups**
   c. The value one level higher than the highest **test group**

Here, the 0 g Salt/100 mL Water represents a control group that has not been treated with the independent variable (Salt Water Concentration)

Example 1:

Independent Variable	Test Groups
Color of Light	White (control group)
	Red
	Orange
	Yellow
	Green
	Blue
	Indigo

Example 2:

Independent Variable	Test Groups
Salt Water Concentration	0 g Salt/100 mL Water
	1 g Salt/100 mL Water
	2 g Salt /100 mL Water
	3 g Salt/100 mL Water
	4 g Salt/100 mL Water
	5 g Salt/100 mL Water
	6 g Salt/100mL Water

Example 3:

Independent Variable	Test Groups
Seed Planting Separation	0 cm
	2 cm
	4 cm (control group)
	6 cm
	8 cm
	10 cm
	12 cm

Since White light is a combination of all the other colors, it represents a control group with an average treatment.

Seed planting separation is something that can be easily researched for just about any kind of seed. In other words, there is a normal value used when planting a particular type of seed in soil. This normal value will be the control group in this example.

Scenario Example 5

Control Group/Test Groups

Independent Variable	Control Group	Test Group 1	Test Group 2	Test Group 3	Test Group 4
Hand Sanitizer Usage Frequency	0 Times/Week	1 Time/Week	2 Times/Week	3 Times/Week	4 Times/Week

Breakdown of Control Group

1. Once you have decided upon an **independent variable**, do research to find whether there is a **normal or recommended** setting/value for this factor regarding the experiment you are planning.
   a. If there is a **normal setting** for this factor, make that setting your **control group**.
      i. *There is no normal setting/value for this factor. Proceed to 1.b.*
   b. If there is **no normal setting**, proceed to step 2.
2. Give the control group a "0" setting if:
   a. If it is normal to not treat the test subject with the **independent variable**.
      i. *While many people use hand sanitizer, there are many people who do not. Therefore, there is no real normal course of action. "0" setting (0 Times/Week) is acceptable.*
   b. Treatment with the **independent variable** is not known to be a vital factor required by the experiment to get meaningful measurement.
      i. *Treatment with hand sanitizer is not known to be a vital factor required to obtain meaningful measurement. "0" setting (0 Times/Week) is acceptable.*

Practice Setting the Control Group

Independent Variable	Control Group	Test Group 1	Test Group 2	Test Group 3	Test Group 4
Incline Angle		15°	20°	25°	30°
Daily Sunlight Exposure		5 hours	8 hours	11 hours	14 hours
Environmental Temperature		5°Celcius	10°Celcius	15°Celcius	20°Celcius
Volume of Water in Bottle		30 milliliters	60 milliliters	90 milliliters	120 milliliters
Relative Humidity		10%	20%	30%	40%
Average Wind Speed		5 km/hour	10 km/hour	15 km/hour	20 km/hour
Acuity of Vision		20/30	20/40	20/50	20/60
Drop Height		2 meters above surface	3 meters above surface	4 meters above surface	5 meters above surface
Time Allowed for Reaction to Take Place		90 seconds	120 seconds	150 seconds	180 seconds
Your Experiment:					

Worksheet: Independent Variable (Due Oct. 6)

Directions: Identify the independent variable and how it will be changed.

---

1. Independent Variable (What factor will you set at different levels before your experiment?):

   ____

   a. Control Group (What is the normal level/setting for the independent variable?)

      ____

   b. Test Group 1 (What is the second level/setting for the independent variable?)

      ____

   c. Test Group 2 (What is the third level/setting for the independent variable?)

      ____

   d. Test Group 3 (What is the fourth level/setting for the independent variable?)

      ____

   e. Test Group 4 (What is the fifth level/setting for the independent variable?)

      ____

   f. Test Group 5 (What is the sixth level/setting for the independent variable?)

      ____

Identifying the Dependent Variable

As stated above, a good **problem statement** asks about a cause-and-effect relationship between the **independent variable** and the **dependent variable**. It has been established that the **independent variable** is always the **cause**. Therefore, the **dependent variable** will always be the effect. Think of this variable as what you will have to observe and measure during and at the end of the **experiment**.

A good procedure to determine your dependent variable is as follows:

1. Research your topic. During your research, identify things that have the following two properties:
   - Will be affected by a change in the **independent variable**
   - Is measurable
2. List all things in your research that you find to meet both of these requirements and choose one. This will be your dependent variable.

Scenario Example 6

Dependent Variable

Antibiotic resistance in bacteria

Breakdown of Dependent Variable Choice

1. Will be affected by a change in the **independent variable**
   - In the **Purpose**, it is explained that use of hand sanitizer will affect the development of antibiotic resistance in bacteria.
2. Is measurable
   - Bacteria that grow on surfaces that have been treated with hand sanitizer can be assumed to be resistant to the antibiotic in the hand sanitizer.
   - Bacteria generally grow in colonies. These colonies can be measured. These measurements can then be used to calculate the extent of growth of bacteria.
   - The extent to which bacteria from hand sanitizer treated surfaces grow indicates the extent of antibiotic resistance.

Planning to Measure the Dependent Variable

The **dependent variable** is the factor that may be affected by the change that was made to the **independent variable**. It is important that this factor is measured multiple times for all settings of the **independent variable**. Those measurements will be recorded into data tables to begin the process of data analysis. Appropriate and accurate measurement of the **dependent variable** or an indicator of the **dependent variable** is necessary to write a **conclusion** that best states the answer to the central question – the **problem statement**. A plan for this measurement must be developed before experimentation begins. The plan should include what will be measured, the units that will be used, the tool to be used to make the measurement, and a description of how the measurement relates to the dependent variable.

Scenario Example 7

Dependent Variable

Antibiotic resistance in bacteria

Measurement

Bacterial colony diameters

Units

Millimeters (mm)

Tool

Metric Ruler

Description of Relationship Between Dependent Variable and Measurement

Bacterial colonies tend to grow in circular shapes. The diameter of these colonies can be measured to calculate the area of the colony using the formula:

$$A = \pi r^2$$

The area of the colonies is directly related to the extent to which the bacteria are able to grow. The ability to grow on hand sanitizer treated surfaces demonstrates antibiotic resistance in bacteria.

Worksheet: Dependent Variable (Due Oct. 6)

Directions: Identify the dependent variable and develop a plan to measure it.

---

1. Dependent Variable (What will be the result of your experiment):

   ____

   a. Measurement (What will be measured to indicate the result of your experiment?)

      ____

   b. Units (As what metric units will your measurement be reported?)

      ____

   c. Tool (What tool will you use to make these measurements?)

      ____

   d. Relationship (Describe the relationship between the dependent variable and the measurement you will make to indicate the dependent variable.)

      ____

      ____

      ____

      ____

      ____

      ____

      ____

      ____

      ____

      ____

Worksheet: Problem Statement (Due Oct. 6)

Directions: Write a problem statement by asking how your independent variable affects your dependent variable.

1. Review your independent and dependent variables.
2. Plug your independent and dependent variables into the problem statement template.

OR

3. If your variables do not fit the given format, reword the question with an alternative format.

- Independent Variable: ____

- Dependent Variable: ____

Problem Statement Template:

Does ____
(Independent Variable)

affect ____?
(Dependent Variable)

OR

Form your own Problem Statement:

____

____

____

____

The Hypothesis: A Preliminary Answer to the Problem Statement

The **problem statement** is a question. When a question is asked, the natural order of things would be to research information surrounding the topic. Then, with that information, you would provide an answer to the question. That is exactly what the **hypothesis** is. It is a preliminary answer to the question asked in the **problem statement**. In this case, "preliminary" refers to the fact that no experimentation has been performed.

Hypotheses take two forms:

- **Alternative Hypothesis (H_1):** In this form, the researcher states that changing the independent variable in a certain way (usually by increasing or decreasing it) will change the dependent variable in a certain way (usually by increasing or decreasing it). Just as the **problem statement** poses a question about a cause-and-effect relationship, the alternative hypothesis provides the preliminary answer as a cause-and-effect relationship.
- **Null Hypothesis (H_0):** This form opposes the alternative hypothesis. The alternative hypothesis states that there will be a different outcome among differently treated groups. The null hypothesis states that there will not be a significant difference in outcome, even if the groups are treated differently. Essentially, the null hypothesis is stating that there is no cause-and-effect relationship between the variables.

You should always state both hypotheses. In the conclusion of your project, you will accept or reject the null hypothesis. Accepting the null hypothesis nullifies the alternative hypothesis. Rejecting the null hypothesis signifies a cause-and-effect relationship. However, it does not necessarily mean that the alternative hypothesis is supported. The only way to determine whether to support or reject the alternative hypothesis is to analyze trends in the data from experimentation.

Scenario Example 8

Problem Statement

Does the frequency of hand sanitizer use affect antibiotic resistance in bacteria?

Null Hypothesis (H_0)

There is not a significant difference in antibiotic resistance of bacterial cultures whose lines have been exposed to varying frequencies of hand sanitizer usage.

Alternative Hypothesis (H_1)

Increasing the frequency of use of hand sanitizer will increase antibiotic resistance in bacterial lines.

Worksheet: Wording the Alternative Hypothesis (Due Oct. 6)

Directions: Develop an alternative hypothesis for your investigation. Follow the instructions below to do so.

1. Identify your independent variable and choose how best to describe its change.
    a. **Directional Change:** Can your independent variable be increased or decreased to change the dependent variable?
        i. No: leave the first table blank. Go to (1.b.).
        ii. Yes: Fill in the following table.

Independent Variable	Choose how to change the independent variable	Increases/Decreases

    b. **Qualitative Setting:** Provide the independent variable setting (Usually the control group) that you think will maximize the desired outcome in the dependent variable?

Optimum Setting for Independent Variable

2. Identify your dependent variable and choose the best way to describe how it changes.
    a. **Directional Difference:** Can your dependent variable increase or decrease resulting from change in the independent variable?
        i. No: leave the first table blank. Go to (2.b.).
        ii. Yes: Fill in the following table.

Dependent Variable	How do you think the change in the independent variable will change the dependent variable?	Will Increase/Will Decrease

    b. Qualitative Outcome: Provide the optimal descriptive outcome for the dependent variable.

Ideal Outcome for Dependent Variable

Worksheet: Null and Alternative Hypotheses (Due Oct. 6)

Directions: Develop a null and alternative hypothesis for your investigation.

1. Rewrite your problem statement.

____

____

____

2. **Null Hypothesis (H_0):** Write a hypothesis stating that there will not be a difference in the dependent variable when the independent variable is changed.

____

____

____

____

3. **Alternative Hypothesis (H_1):**
    a. Write a hypothesis that answers the question asked in the problem statement making sure that the answer states how changing the independent variable will change the dependent variable. (Use answers on previous worksheet to form your hypothesis.)

____

____

____

____

OR

    a. Write a hypothesis that answers the question asked in the problem statement by stating that a specific setting of the independent variable will cause the ideal effect on the dependent variable. (Use answers on previous worksheet to form your hypothesis.)

____

____

____

____

Controlled Variables: Keeping Variables Constant

In any experiment, the aim is to determine how changing the independent variable will affect change in the dependent variable. To correctly determine the independent variable's effect on the dependent variable, the experimenter must be certain that all variables (besides the independent variable) that could affect the dependent variable remain constant throughout the experiment. These constants are the controlled variables. When the experimenter adequately **keeps the controlled variables constant**, any change seen in the **dependent variable** can reasonably be attributable to the change in the one variable, the **independent variable**, that the experimenter changed.

Scenario Example 9

Controlled Variables (Constants)	Reasoning
Type of hand sanitizer	*Different **types of hand sanitizer** can vary in the antibiotic agent that they use and/or the dosage in the product. Different antibiotics can therefore change the extent to which bacteria develop resistance. Changing the type and/or brand of hand sanitizer across test groups would not be good practice*
Incubation Temperature	*Different **incubation temperatures** can have a major effect on the ability for bacteria to grow. Therefore, varying the temperature across test groups could drastically change the culture sizes. And therefore, the extent to which bacteria develops antibiotic resistance. This would not be good practice.*
Bacterial Source	*Different **bacterial sources** come from different environments to which they will be best adapted. Therefore, the use of bacteria from different sources across test groups could change the extent to which the bacterial cultures grow – the indicator of antibiotic resistance in bacteria. This would not be good practice.*
Bacterial Growth Medium	*Different **bacterial growth media** will vary in the nutrients on which the bacteria feed. Different nutritional diets can change the resulting bacterial colony sizes – the indicator of antibiotic resistance in bacteria. Changing the growth medium across test groups would not be good practice.*

Worksheet: Experimental Design (Due Oct. 13)

Directions: Use your prior worksheets to complete the following experimental design.

---

1. Problem Statement: ____

   ____

2. Null Hypothesis (H_0): ____

   ____

3. Alternative Hypothesis (H_1): ____

   ____

4. Independent Variable ____
   a. Control Group: ______________________________________# of Trials _____
   b. Test Group 1: ______________________________________# of Trials _____
   c. Test Group 2: ______________________________________# of Trials _____
   d. Test Group 3: ______________________________________# of Trials _____
   e. Test Group 4: ______________________________________# of Trials _____
   f. Test Group 5 _______________________________________# of Trials _____
5. Dependent Variable ____
   a. Measurement (Units): ____
   b. Measuring devise: ____
   c. Describe how this measurement relates to your dependent variable.

      ____

      ____

      ____

      ____

      ____

6. Controlled Variables
   a. Controlled Variable 1: ____
   b. Controlled Variable 2: ____
   c. Controlled Variable 3: ____
   d. Controlled Variable 4: ____
   e. Controlled Variable 5: ____

Literature Review

Conducting a **literature review** of your topic is necessary in order to design an investigation that yields sound interpretable data. The process should be thought of as preparation. You want to know as much about what you are studying as you can. In that way, you become an expert, or at least, a well-educated person within the field you are studying.

Research Questions

Think of a literature review as finding the answers to questions that have been asked. With textbooks, journals, teachers, field experts, the advent of the Internet and other scholarly sources, finding the answers is usually the easiest part of this endeavor for most students. However, the difficulty arises in figuring out what questions should be asked. While every project will have specific questions, the following questions can serve as a guideline to begin the process.

1. ***What are the general facts about the topic?*** You should begin your research by educating yourself about your topic. This information will help you understand the scientific aspect of your investigation. From this understanding you should gain further insight about how variables may be changed and how they may be affected.
2. ***Is there an optimal setting for the independent variable?*** Given the independent variable that the investigator has chosen, this question seeks to find out very directly whether another investigation has determined a best setting for the independent variable. If such information is found, it may be used to develop the hypothesis.
3. ***How is the dependent variable measured?*** Measurement is an important part of all projects. Values of the dependent variable must be determined. In order to do this, you must know the type of measurements to make, the tool you will use to make the measurement, and the units of the values.
4. ***What materials are needed to conduct the experiment?*** While many materials for many experiments may be obvious to someone who has planned an experiment, there are usually underlying tools and materials that are not known – especially if the topic of investigation is new to the investigator.
5. ***What safety precautions should be taken for the investigation?*** In scientific investigations, safety trumps everything else. The investigator should take special care to know and follow all safety guidelines specific to their investigation.

6. ***What have other people done in the area of the current investigation and what were their findings?*** An imperative part of the world of science is that scientists build upon the body of knowledge that already exists. This means that rarely, is there an investigation of a completely new phenomenon. If your investigation is new, the chances are that at least a similar investigation has already been done. Determining the findings of previous investigations could serve to give insight into your investigation.
7. ***What are the facts, meanings, and implications of words/phrases/concepts uncovered during the literature review?*** The goal of conducting a literature review is to learn new information. When that new information comes about, do not hesitate to direct your research toward finding more information about these sub-topics. They could lead you to critical information for your investigation.
8. ***What is the source of the researched information?*** This question is not necessarily a research question, but should be the question asked and answered for each of the sources of information that you use in the process of your literature review. You will need this information to compose your Works Cited page in your research paper.

Scenario Example 10

Research Questions

1. *What are the general facts about the topic?*
    a. What are bacteria?
    b. What do bacteria look like?
    c. What are bacteria made of?
    d. Where do bacteria live?
    e. Are all bacteria bad?
    f. What do bacteria do in their environments?
    g. How can I grow and take care of bacteria?
    h. What is antibiotic resistance?
    i. What is hand sanitizer?
    j. For what is hand sanitizer used?
2. *How is the dependent variable measured?*
    a. How do you measure bacterial colony growth?
    b. In what units will the measurement be?
    c. What tools will I need to measure bacterial colony growth?

3. *Is there an optimal setting for the independent variable?*
    a. What are the directions for use of hand sanitizer?
    b. How frequently do experts say you should use hand sanitizer?
    c. When should you not use hand sanitizer?
4. *What materials are needed to conduct the experiment?*
    a. What tools are needed to grow bacteria?
    b. What materials are needed to grow bacteria?
5. *What safety precautions should be taken for the investigation?*
    a. What dangers exist in growing bacterial cultures?
    b. How can one protect oneself when growing bacterial cultures?
    c. What laboratory safety gear should be worn while growing bacterial cultures?
6. *What other studies have been done around the current investigation and what were their findings?*
    a. What are some experiments that have been conducted about hand sanitizer usage and the effects on bacteria?
    b. Are there any current studies on the effects of hand sanitizer on bacteria?
7. *What are the facts, meanings, and implications of words/phrases/concepts uncovered during the literature review?*
    a. What is a petri dish and agar?
    b. What is the aseptic technique?
    c. What does prokaryotic mean?
8. *What is the source of the researched information?*
    a. From what type of source did the information come?
    b. Who is the author of, or person interviewed for the information?
    c. What is the name of the book, periodical/journal, newspaper, website/webpage, information?
    d. What company published the information, in what city, and when?
    e. What is the name of the publication?

Worksheet: Literature Review # 1 (Due Oct. 26)

Directions: Use the question prompt to form your first research question. Research to answer the question. Write the appropriate source information.

Question Prompt: *Ask a general question about your main topic.*

Question 1: ____

____

Answer: ____

____

____

____

____

____

Author/Interviewee	
Title	
Interviewer	
Year	
Publisher	
City	
Journal/Periodical Name	
Webpage	
Website	
Month, Day, and Year Accessed	
Pages	
URL	

Worksheet: Literature Review # 2 (Due Oct. 26)

Directions: Use the question prompt to form your first research question. Research to answer the question. Write the appropriate source information.

Question Prompt: *Ask questions about how to measure your dependent variable.*

Question 2: ____

____

Answer: ____

____

____

____

____

____

Author/Interviewee	
Title	
Interviewer	
Year	
Publisher	
City	
Journal/Periodical Name	
Webpage	
Website	
Month, Day, and Year Accessed	
Pages	
URL	

Worksheet: Literature Review # 3 (Due Oct. 26)

Directions: Use the question prompt to form your first research question. Research to answer the question. Write the appropriate source information.

Question Prompt: *Ask questions about setting the independent variable*.

Question 3: ____

____

Answer: ____

____

____

____

____

____

Author/Interviewee	
Title	
Interviewer	
Year	
Publisher	
City	
Journal/Periodical Name	
Webpage	
Website	
Month, Day, and Year Accessed	
Pages	
URL	

Worksheet: Literature Review # 4 (Due Oct. 26)

Directions: Use the question prompt to form your first research question. Research to answer the question. Write the appropriate source information.

Question Prompt: *Ask questions about the materials needed to conduct your experiment.*

Question 4: ____

____

Answer: ____

____

____

____

____

____

Author/Interviewee	
Title	
Interviewer	
Year	
Publisher	
City	
Journal/Periodical Name	
Webpage	
Website	
Month, Day, and Year Accessed	
Pages	
URL	

Worksheet: Literature Review # 5 (Due Oct. 26)

Directions: Use the question prompt to form your first research question. Research to answer the question. Write the appropriate source information.

Question Prompt: *Ask questions about safety procedures for your experiment.*

Question 5: ____

____

Answer: ____

____

____

____

____

____

Author/Interviewee	
Title	
Interviewer	
Year	
Publisher	
City	
Journal/Periodical Name	
Webpage	
Website	
Month, Day, and Year Accessed	
Pages	
URL	

Worksheet: Literature Review # 6 (Due Oct. 26)

Directions: Use the question prompt to form your first research question. Research to answer the question. Write the appropriate source information.

Question Prompt: *Ask questions about other studies that have been done around your topic.*

Question 6: ____

____

Answer: ____

____

____

____

____

____

Author/Interviewee	
Title	
Interviewer	
Year	
Publisher	
City	
Journal/Periodical Name	
Webpage	
Website	
Month, Day, and Year Accessed	
Pages	
URL	

Worksheet: Literature Review # 7 (Due Oct. 26)

Directions: Use the question prompt to form your first research question. Research to answer the question. Write the appropriate source information.

Question Prompt: *Ask about information uncovered while doing your research.*

Question 7: ____

____

Answer: ____

____

____

____

____

____

Author/Interviewee	
Title	
Interviewer	
Year	
Publisher	
City	
Journal/Periodical Name	
Webpage	
Website	
Month, Day, and Year Accessed	
Pages	
URL	

Worksheet: Literature Review # 8 (Due Oct. 26)

Directions: Use the question prompt to form your first research question. Research to answer the question. Write the appropriate source information.

Question Prompt: *Ask about information uncovered while doing your research.*

Question 8: ____

____

Answer: ____

____

____

____

____

____

Author/Interviewee	
Title	
Interviewer	
Year	
Publisher	
City	
Journal/Periodical Name	
Webpage	
Website	
Month, Day, and Year Accessed	
Pages	
URL	

Worksheet: Literature Review # 9 (Due Oct. 26)

Directions: Use the question prompt to form your first research question. Research to answer the question. Write the appropriate source information.

Question Prompt: *Ask about information uncovered while doing your research.*

Question 9: ____

____

Answer: ____

____

____

____

____

____

Author/Interviewee	
Title	
Interviewer	
Year	
Publisher	
City	
Journal/Periodical Name	
Webpage	
Website	
Month, Day, and Year Accessed	
Pages	
URL	

Worksheet: Literature Review # 10 (Due Oct. 26)

Directions: Use the question prompt to form your first research question. Research to answer the question. Write the appropriate source information.

Question Prompt: *Ask about information uncovered while doing your research.*

Question 10: ____

____

Answer: ____

____

____

____

____

____

Author/Interviewee	
Title	
Interviewer	
Year	
Publisher	
City	
Journal/Periodical Name	
Webpage	
Website	
Month, Day, and Year Accessed	
Pages	
URL	

APA Source Component Guide

Directions: Use the following grid to complete your bibliography information on the previous pages for the various sources of information that you have obtained from your research. The white boxes across a row are necessary fields for each source type

Source	Author/ Interviewee	Title	Interviewer	Year	City	Publisher	Journal/ Periodical Name	Web Page	Web Site	Month/Day/ Year	Pages	URL
Book	Include	Include		Include	Include	Include						
Interview	Include	Include	Include							Include		
Web Site	Include							Include	Include	Include		Include
Periodical	Include	Include					Include			Include	Include	
Journal	Include	Include		Include			Include				Include	

Tools and Materials

In order to carry out your experiment, you will need a combination of tools and materials. Tools are generally those items that will not be used up during your experimentation whereas materials will be. Knowing what you will need may or may not be obvious. Those things that are not obvious may be determined while conducting your literature review. Your ability to secure the proper materials may determine whether or not you will be able to do your project.

Scenario Example 11

Tool/Material	Purpose	Obtainable or Teacher-Assisted	Quantity	Cost
Petri Dish	Container for bacteria	Teacher Assisted	30	$25.39
Sugar	Ingredient in bacterial growth agar	Obtainable	75 mL	$3.59
Beef Bullion	Ingredient in bacterial growth agar	Obtainable	15 cubes	$5.00
Clear Gelatin	Ingredient in bacterial growth agar	Obtainable	15 packs	$21.00
Sterile Cotton Swabs	Smear bacterial samples	Teacher-Assisted	30	$10.00
Graduated Cylinder	Measure ingredients	Teacher-Assisted	1	$0.00
Metric Ruler	Measure bacterial colonies	Teacher-Assisted	1	$0.00
Hot Plate	Heat agar mixture	Teacher-Assisted	1	$0.00
Incubator	Provide optimal growth temperature	Teacher-Assisted	1	$0.00
Beaker	Container for agar mixture	Teacher-Assisted	1	$0.00

Worksheet: Materials List (Due Oct. 26)

Directions: Use the following table to list the tools and materials you will need to complete your experiment.

Tool/Material	Purpose	Obtainable or Teacher-Assisted	Quantity	Cost