STEM @ Root
Scientific Method Guided Worksheet
3-5th grade

Project Title (Can be your Research Question):

Example: Pinto Bean Miracle Grow Experiment

Research Question (Purpose)

Ask a Question: The scientific method starts when you ask a question about something that you observe: How, What, When, Who, Which, Why, or Where? In order for the scientific method to answer the question, it must be about something that you can **measure,** preferably with a **number.** Also ask yourself, "Is this question interesting enough to want to read about and work on for the next month?"

Example: Does Miracle Grow help make plants grow taller?

Background Research

Rather than starting from scratch in putting together a plan for answering your question, you want to be a savvy scientist using library and Internet research to help you find the best way to do things and insure that you don't repeat mistakes from the past. Try to use at least 3 resources and be sure to look up words/terms that you do not know.

The Key Goal: Obtain enough information to make a prediction of what will happen in the experiment.

Example: Research-What is Miracle Grow? What is fertilizer? What kind of plants are good to use in experiments? What materials do I need to grow a plant from a seed? What do plants need to grow?

Hypothesis

Construct a Hypothesis: A hypothesis is an educated guess about how things work:
"If _____[I do this] _____, then _____[this]_____ will happen."

You must state your hypothesis in a way that you can **easily measure**, and of course, your hypothesis should be constructed in a way to help you answer your original question.

Example: If I give plants Miracle Grow, **then** the plants will grow taller. **OR** Plants will grow taller when given Miracle Grow.

Experimental Design

The first step of designing your experimental procedure involves planning how you will change your independent variable and how you will measure the impact that this change has on the dependent variable. To guarantee a fair test when you are conducting your experiment, you need to make sure that the only thing you change is the independent variable. All the controlled variables **must remain constant.** Only then can you be sure that the change you make to the independent variable actually caused the changes you observe in the dependent variables.

Experimental Group-receives some kind of treatment or condition

Control Group-receives no treatment, used to compare

Everything about the two groups except the factor you are testing should remain exactly the same.

Example:

Experimental Group	Control Group
Plants A	Plants B
Receive Miracle Grow (treatment)	Do **not** receive Miracle Grow (no treatment)
light, water, storage temperature (same)	light, water, storage temperature (same)

Identify your Variables

Independent Variable	Dependent Variables	Controlled Variable
What will you be changing in the experiment? *NOTE: You should only have one independent variable: ex: Miracle Grow	What will you be measuring or observing? *NOTE: The number of the dependent variables in an experiment varies-often more than one. ex: height of plant	What you will keep the same throughout experiment? *NOTE: Most experiments have more than one controlled variable: ex: amount of light amount of water source of water storage temperature amount of soil in each pot type of seed planted number of seeds planted
Your experiment:	Your experiment:	Your experiment:

Materials List

What type of supplies and equipment will you need to complete your science fair project? By making a complete list ahead of time, you can make sure that you have everything on hand when you need it. Some items may take time to obtain, so making a materials list in advance represents good planning!

Make the materials list **as specific as possible** and be sure you can get everything you need before you start your project.

Example: 18 Pinto beans, 6 identical pots, labels, two 2 liter bottles, 4 liters plain water, 50 grams of Miracle Grow, Meter Stick, Pencil and Calendar, enough potting soil for 6 pots

Procedure

Write the experimental procedure like a step-by-step recipe for your science experiment. A good procedure is so detailed and complete that it lets someone else duplicate your experiment exactly!

Example:

1. Gather all your materials.
2. Label you pots: A1, A2, A3 and B1, B2, B3
3. Fill each pot with equal amounts of potting soil.
4. Label each watering 2 liter container: "PW" and the other "MG"
5. Add 2 liters plain water to the container labeled "PW"
6. Add 2 liters plain water **AND** 50 g Miracle Grow to the bottle labeled "MG"
7. Plant 3 pinto beans into each of the 6 pots. They should be 2 centimeters deep.
8. Pour 50 mL of water into pots A1, A2, A3 with the water in liter "MG" once a day.
9. Pour 50 mL of water into pot B1, B2, B3 with the water in liter "WP"once a day.
10. Place all the pots next to each other so that they will get equal amounts of sun.
11. Observe and record the growth of the plant on a weekly basis for 4 weeks.

Perform the Experiment

Your experiment tests whether your hypothesis is true or false. It is important for your experiment to be a fair test. You conduct a fair test by making sure that you change only one factor at a time while keeping all other conditions the same. It's ok if the first experiment goes wrong and you have to modify the procedure. It's ok if the experiment disproves your hypothesis. Think Safety! It takes time!

Repeating a science experiment is an important step to verify that your results are consistent and not just an accident.

- For a typical experiment, you should plan to repeat it **at least three times**
- If you are doing something like growing plants, then you should do the experiment on at least three plants in separate pots (=experiment x3)
- If you are doing an experiment that involves testing or surveying different groups, you won't need to repeat the experiment three times, but you will need to test or survey a sufficient number of participants to insure that your results are reliable. You will almost always need many more than three participants!

Example: Follow your procedure step 1-11 for Miracle Grow Experiment written above.

Observations

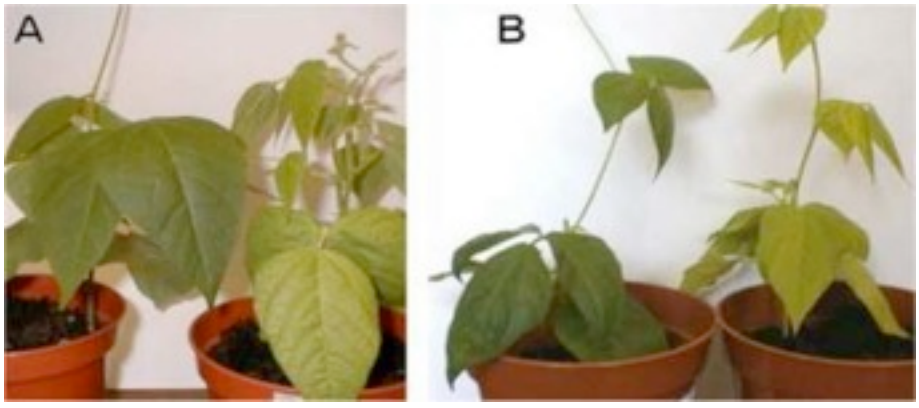
- If you haven't already, obtain a **notebook** to record all of your observations during your experiment.
- Before starting your experiment, prepare a **data table** so you can quickly write down your measurements as you observe them.
- Follow your experimental procedure exactly. If you need to make changes in the procedure (which often happens), write down the changes exactly as you made them.
- Be consistent, careful, and accurate when you take your measurements. Numerical measurements are best.
- Take pictures of your experiment for use on your display board if you can.

[1]

Example: Data Table of plant growth observations

	Start 3/11/2012	Week 1 3/18/2012	Week 2 3/25/2012	Week 3 4/1/2012	Week 4 4/8/12
Plant A1	0 cm	4 cm	6 cm	14 cm	20 cm
Plant A2	0 cm	6 cm	10 cm	17 cm	21 cm
Plant A3	0 cm	4 cm	6 cm	13 cm	19 cm
Plant B1	0 cm	3 cm	5 cm	10 cm	15 cm
Plant B2	0 cm	2 cm	4 cm	9 cm	13 cm
Plant B3	0 cm	1 cm	3 cm	8 cm	13 cm

Example: Pictures of Plants in Group A and B



Data

- **Review** your data. Try to look at the results of your experiment with a critical eye. Ask yourself these questions:

    - Is it complete, or did you forget something?
    - Do you need to collect more data?
    - Did you make any mistakes?

Calculate an average for the different trials of your experiment, if appropriate.

Example of Averaging Data

Week 1 for experimental group: Add together A1 + A2 + A3 for week 1
4 cm + 6 cm + 4 cm = 14 cm
14 cm ÷ 3 = 4.66 cm
4.66 cm rounded up to the nearest whole number = 5 cm

Experimental group	Start 3/11/2012	Week 1 3/18/2012	Week 2 3/25/2012	Week 3 4/1/2012	Week 4 4/8/12
Plant A1	0 cm	4 cm	6 cm	14 cm	20 cm
Plant A2	0 cm	6 cm	10 cm	17 cm	21 cm
Plant A3	0 cm	4 cm	6 cm	13 cm	19 cm
Average	0 cm	5 cm	7 cm	15 cm	20 cm

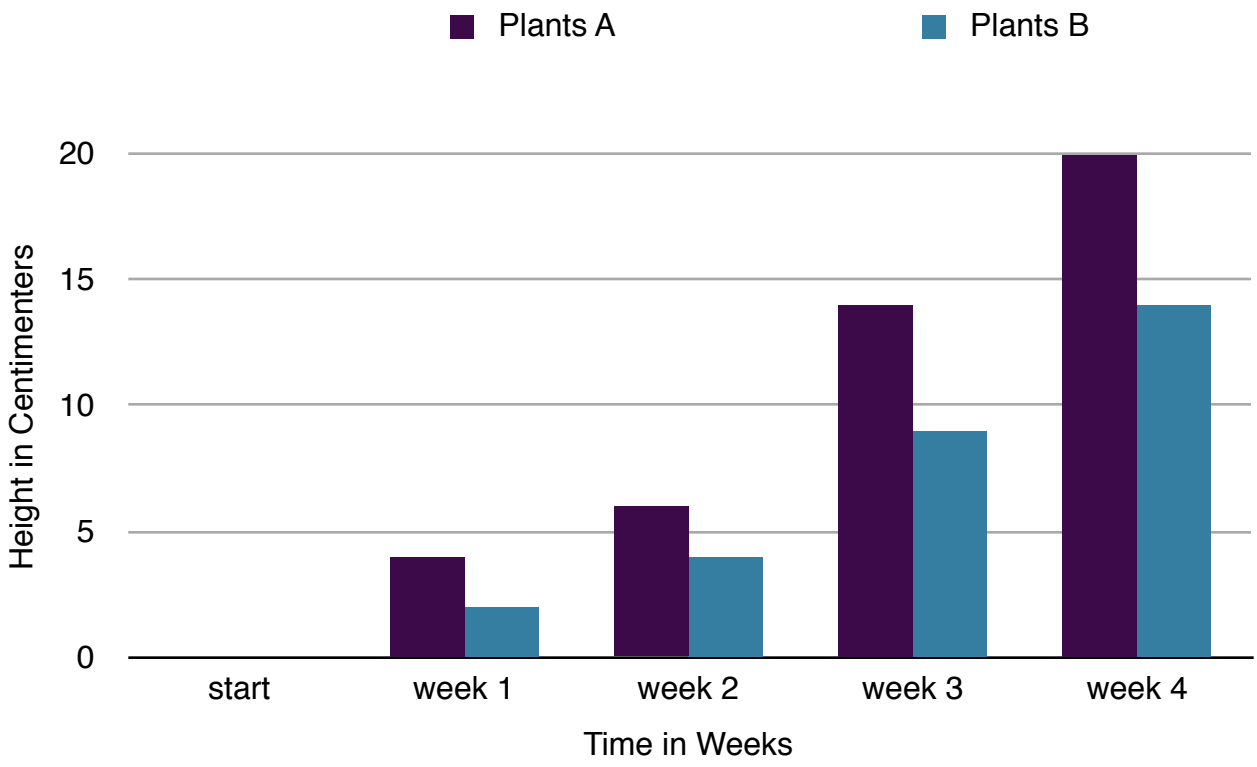
Control Group	Start 3/11/2012	Week 1 3/18/2012	Week 2 3/25/2012	Week 3 4/1/2012	Week 4 4/8/12
Plant B1	0 cm	3 cm	5 cm	10 cm	15 cm
Plant B2	0 cm	2 cm	4 cm	9 cm	13 cm
Plant B3	0 cm	1 cm	3 cm	8 cm	13 cm
Average	0 cm	2 cm	4 cm	9 cm	14 cm

Chart/Graph/Table:

Graphs are often an excellent way to display your results. They create a professional appearance and convey a great deal of information. Examples include: Bar Graph, Pie Chart, X & Y axis Graph, Histogram, etc. In fact, most good science fair projects have at least one graph.

For any type of graph:

- Generally, you should place your independent variable on the x-axis of your graph and the dependent variable on the y-axis.
- Be sure to label the axis of your graph– don't forget to include the units of measurement (grams, centimeters, liters, etc.).
- If you have more than one set of data, show each series in a different color or symbol and include a legend with clear labels.



Plant Growth over Time

Results

The results are usually written in the form of a statement that explains or interprets the data. You do not go into any detail or explanations here. You simply write in words what your data is telling you.

Example: The plants in Group A grew taller than the plants in Group B. The Plants that received the Miracle Grow/water mixture grew an average of 6 cm taller than the plants that only received water.

Conclusion

Your **conclusions** summarize how your results support or contradict your original hypothesis:

- Summarize your science fair project results in a few sentences and use this summary to support your conclusion. Include key facts from your background research to help explain your results as needed.
- State whether your results support or contradict your hypothesis. (Engineering & programming projects should state whether they met their design criteria.)
- If appropriate, state the relationship between the independent and dependent variable.
- Summarize and evaluate your experimental procedure, making comments about its success and effectiveness.
- Suggest changes in the experimental procedure (or design) and/or possibilities for further study

Example: Miracle grow helps make plants grow taller. I thought that the Miracle grow would help make the plants grow taller and my hypothesis was correct.. I learned that a water mixture with Miracle Grow grew pinto bean plants better than pinto bean plants given plain water. Fertilizers contain Nitrogen, Phosporous and Potassium, which are important nutrients that all plants need to grow. When plants die in nature, these nutrients are absorbed in the soil and help other plants to grow. When a plant is planted in a pot and not in the ground, they need soil that has extra nutrients to help them grow. Further study could be comparing other brands of fertilizers.

Resources

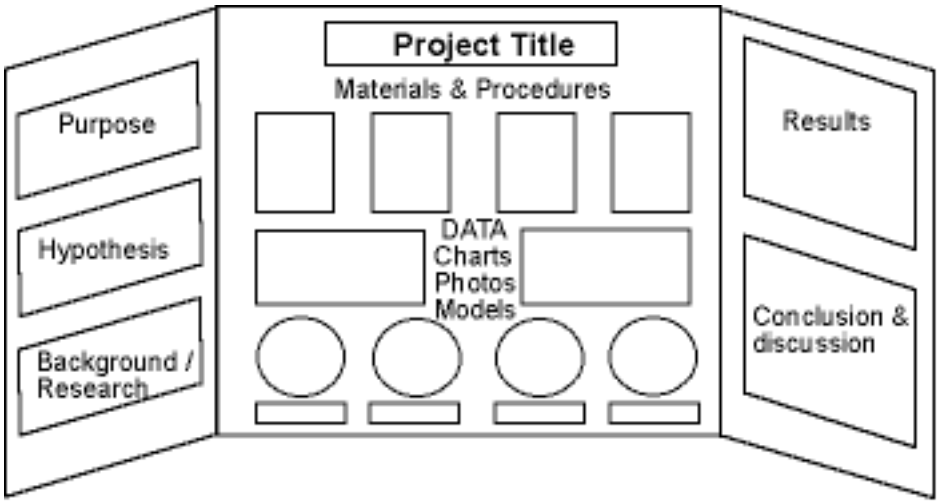
One of the most important things for a student to do is recognize the people and resources used in developing and conducting the project. List the people who offered knowledge or helped, and list web sites, retail stores, magazines, books, computer programs, etc. that were used as sources of information or supplies.

Example:

www.sciencebuddies.com
www.biologycorner.com
www.home.howstuffworks.com/question181.htm
Mentors Name
Media Specialists Name
Parents Name
Name of Book and Author

Project Board Layout

Organize your information like a newspaper so that your audience can quickly follow the thread of your experiment by reading from top to bottom, then left to right. Include each step of your science fair project: Project Title, Question (purpose), Hypothesis, Variables (identify in your data), Background Research, and so on.



For more information on the Scientific Method and science fair projects, visit
www.sciencebuddies.org/science-fair-projects/project_scientific_method