



What is Scientific Inquiry?

Subject/ target grade: Middle School (8th grade) Earth Science

Duration: Three 50 minute periods

Setting: Classroom and computer lab

Materials and Equipment Needed:

Per class

- ◆ Computers with Microsoft Excel and MS PowerPoint
- ◆ Printer with paper

Per group

- ◆ 3 fun size bags of M&M candies

Per student

- ◆ Scientific Inquiry Worksheet Packet:
 - Scientific Method Worksheet
 - Bikini Bottom Experiments
 - M&M Lab Instructions
 - Lab Report Presentation Guidelines
 - Lab Report Presentation Grading Rubric
 - Scientific Method Word Search

Learning Objectives:

- ◆ Use observations to develop testable, scientific questions.
- ◆ Convert questions into formalized hypotheses.
- ◆ Correctly define the steps in the scientific method.
- ◆ Use a question they generated to conduct a scientific experiment.
- ◆ Gather data, draw conclusions from that data, and evaluate their experiment.

Lesson Overview: Students will review the processes involved in the scientific method. The instructor will then lead students through each step of the scientific method as they complete a short investigation into the distribution of colors of M&M candies in a fun size bag. Students will practice their open inquiry skills as they test and develop their experimental protocol. Students will then summarize their experiments and share their conclusions with the class in a short Microsoft PowerPoint presentation.

Lesson Core

The Guiding Question: How do scientists use the scientific method to conduct research?

Safety precautions: Data collection may aggravate students with a chocolate and possible nut allergy.

Advanced Preparation: Prepare all worksheet packages for each student. Prepare a short presentation to describe and define the steps of the scientific method.

Background Information for Teachers: None required aside from Pre-teaching below.

Important Terms:

- *scientific method*
- *testable question*
- *non-testable question*
- *hypothesis*
- *variable*
- *control group*

Michigan Content Expectations:

E1.1A. Generate new questions that can be investigated in the laboratory or field.

E1.1B. Evaluate the uncertainties or validity of scientific conclusions using an understanding of sources of measurement error, the challenges of controlling variables, accuracy of data analysis, logic of argument, logic of experimental design, and/or the dependence on underlying assumptions.

E1.1D. Identify patterns in data and relate them to theoretical models.

E1.1E. Describe a reason for a given conclusion using evidence from an investigation.

E1.1F. Predict what would happen if the variables, methods, or timing of an investigation were changed.

E1.1G. Based on empirical evidence, explain and critique the reasoning used to draw a scientific conclusion or explanation.

E1.1H. Design and conduct a systematic scientific investigation that tests a hypothesis. Draw conclusions from data presented in charts or tables.

Engage: What guidelines do scientists follow to conduct their research?

Building on prior knowledge:

- ◆ Do scientists have rules to follow when they conduct research?
- ◆ Why do scientists use these rules?
- ◆ What are the steps that scientists follow?
- ◆ Can we do the steps in the scientific method in a different order?
- ◆ What is a hypothesis?
- ◆ What is the difference between a hypothesis and a question?
- ◆ What happens if a hypothesis is not supported by the data you collect?

- ◆ Which of these ways is the most creative?
- ◆ What are the most important sections in a scientific report?

Pre-teaching: Scientists follow a specific method when conducting an investigation. It is called the scientific method. The scientific method is a standardized way of answering and asking scientific questions using research and experiments. Every scientist uses the scientific method to conduct their research so that they may be able to compare their results with those from another scientist.

Handout the student sheet 'Scientific Method Handout' so that students may follow along as you explain the 5 key steps.

There are 5 *steps* in the scientific method:

1. Question- Ask a question about something you observed.
 - ◆ Why, how, or what?
 - ◆ Develop a question that is *testable*, or that can be measured.
 - ◆ Give examples of each and have students determine if it is testable or non-testable. If non-testable, change into a testable question.
 - ◆ Non-testable question: Which vegetables grow better in my garden?
 - ◆ Testable question: Which vegetable seeds will grow fastest in my garden?
2. Hypothesis- An educated guess to explain your observation(s).
 - ◆ A prediction that can be tested in an experiment.

- ◆ Write using an 'If, then' statement.
- ◆ Ex., If _____ [I do this], then _____ [this will happen].
- ◆ Ex., If I plant carrot seeds and tomato seeds, then carrot seeds will germinate quicker.

Important: *the hypothesis must focus on only one variable!*

3. Experiment- a carefully designed procedure to test your hypothesis.
 - ◆ *Change only one variable at a time.*
 - ◆ Does the data you collected support or not support your hypothesis?
 - ◆ Use a control or *control group*. One group must not be changed. This is the standard used for comparison in an experiment.
 - ◆ In order for results to be valid, conduct several tests.
 - ◆ Carefully collect observations and record your data in a data table.
4. Data Analysis- what can your data tell you?
 - ◆ Create graphs or charts to look for trends in your data.
 - ◆ Use the average or mean to compare data between two groups.
5. Conclusion- a summary of your experiment.
 - ◆ Use your data analysis to decide if your observations either *support* or *do not support* your hypothesis.
 - ◆ If your data does not support your hypothesis, give possible reasons to explain this.

- ◆ How could you redesign your experiment with what you have learned? How could you improve your experiment?

Explore:

Day 1- Have students work through the attached worksheet 'Bikini Bottom Experiments' in partners or in small groups. Give the class about 10-15 minutes to develop an answer to the questions. Use the 'Bikini Bottom Experiments Answer Key' to lead a discussion of the possible answers to each of the three questions.

Introduce students to the M&M lab exercise where they will use the scientific method to investigate the distribution of colors in a bag of M&M candies. Hand out a copy of the document 'Scientific Method M&M Lab' to each student. Assign students to read the lab for homework.

Day 2- Assign students into pairs and pass out 1 bag of fun-sized M&Ms to each pair. Explain to students that they will be using the scientific method to determine the distribution of colors in a bag of M&M candies. Hand out one bag of candies to each group

Review the instructions for completing the M&Ms lab. Remind students not to eat the M&Ms until they have completed their data collection. Review the data collection procedures and the methods for calculating percentage. Explain the difference between the values of frequency and percentage.

Point out to the students that they will be collecting their data and then using it to prepare a bar graph in MS Excel. This graph

needs to be attached to the lab when handed in.

Day 3- Have students prepare a short (five slide) MS PowerPoint presentation to share their results with the class.

Explain: At the end of the period, have each pair of students share their hypothesis, results, and conclusions with the class. Ask the class how the pair could have improved upon their experimental design.

Elaboration: This experiment could easily be expanded to encompass a larger data set such as with using a larger bag of M&Ms. In addition, students could be tasked with designing their own experiment that employs the scientific method.

Evaluate: Students will be graded on both their experimental design and presentation using the attached grading rubric. Assign points to each value as desired.

Lesson Closure:

- ◆ What is a hypothesis?
- ◆ What does it mean when your hypothesis is 'wrong'?
- ◆ Why is it important to follow the scientific method?
- ◆ What things are important when collecting data?
- ◆ What did you learn today about experimental design?
- ◆ Can we apply the scientific method to answering questions outside of science?

Lesson Extension

Assessment Options: Hand out the 'Scientific Word Search' for extra credit points.

Additional Resources:

- ◆ The Science Queen (<http://www.thesciencequeen.net/Teachers%20Resources.htm>): a source for lesson plans and middle school science activities.
- ◆ The Science Spot (<http://sciencespot.net/Pages/classgen.html>): great source of lesson plans and activities for science classes.
- ◆ Rap song about the scientific method! (<http://www.youtube.com/watch?v=KZaCy5Z87FA>)
- ◆ They Might Be Giants educational video describing the scientific movie using their song 'Put it to the Test' (<http://www.youtube.com/watch?v=9kf51FpBuXQ&feature=related>)

The Scientific Method

A blueprint for experiment success.

What is the scientific method?

- It is a simple method scientists use to conduct an investigation.
- It is a way to ask & answer scientific questions by asking questions & conducting experiments.

1. Question/Problem

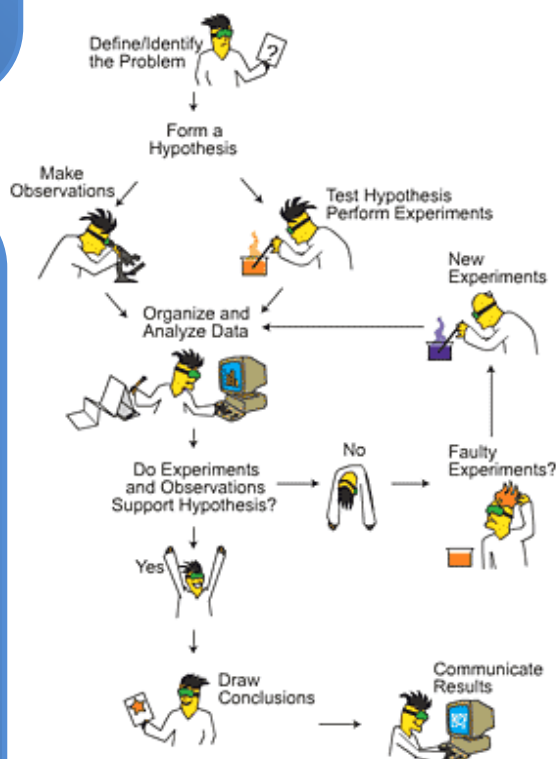
- ◆ Ask a question about something observed.
- ◆ Why?
- ◆ How?
- ◆ What?
- ◆ Question to be solved.
- ◆ Must be about something measurable.

3. Hypothesis

- ◆ Educated guess about how things work.
- ◆ Prediction
- ◆ Use If, then statements
- ◆ If ____ [*I do this*], then ____ [*this will happen*]
- ◆ Focus on one variable only.

2. Experiment

- ◆ Tests your hypothesis.
- ◆ Is it accepted (supported) or rejected (not supported)?
- ◆ Change only one variable at a time.
- ◆ Use a control or control group
- ◆ (A group that has *nothing done to it*. Standard used for comparison in an experiment.)
- ◆ In order for results to be valid, conduct several tests.



5. Conclusions

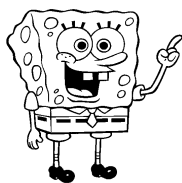
- ◆ Summary of your experiment.
- ◆ After your experiment, analyze your data to see if your hypothesis was accepted or rejected.
- ◆ If hypothesis is rejected, give possible reasons for the difference between your hypothesis and the experimental results.

1. Data Analysis

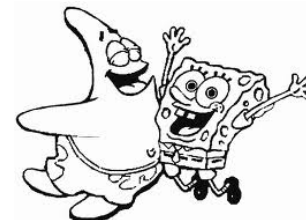
- ◆ Create graphs or charts to look for trends in your data.
- ◆ Use the average or mean to compare data between two groups.

Scientific Method

Name _____



Bikini Bottom Experiments



The Bikini Bottom gang loves science class and wanted to do a little research. Read the description for each experiment and use your knowledge of the scientific method to answer the questions.

◆ Flower Power

SpongeBob loves to garden and wants to grow lots of pink flowers for his pal Sandy. He bought a special Flower Power fertilizer to see if will help plants produce more flowers. He plants two plants of the same size in separate containers with the same amount of potting soil. He places one plant in a sunny window and waters it every day with fertilized water. He places the other plant on a shelf in a closet and waters it with plain water every other day.

→ What did SpongeBob do wrong in this experiment? Explain.

→ What should SpongeBob do to test the effectiveness of Flower Power fertilizer? Write an experiment.

◆ Super Snails

Gary is not the smartest snail in Bikini Bottom and believes he can improve his brain power by eating Super Snail Snacks. In order to test this hypothesis, he recruits SpongeBob and several snail friends to help him with the experiment. The snails ate one snack with each meal every day for three weeks. SpongeBob created a test and gave it to the snails before they started eating the snacks as well as after three weeks.

Test Results		
Snail	Before	After
Gary	64%	80%
Larry	78%	78%
Barry	82%	84%
Terry	72%	70%

→ Based on the data provided, do the Super Snail Snacks work? Explain your answer.

◆ **Bubble Time**

Patrick loves bubble gum and would like to be able to blow bigger bubbles than anyone else in Bikini Bottom. To prepare for the Bikini Bottom Big Bubble Contest, he bought five different brands of bubble gum and needs your help to find the brand that creates the biggest bubbles.

→ Write an experiment to test the bubble power of the bubble gum brands and help Patrick win the contest.

Scientific Method

Answer Key

Bikini Bottom Experiments

The Bikini Bottom gang loves science class and wanted to do a little research. Read the description for each experiment and use your knowledge of the scientific method to answer the questions.

◆ Flower Power

SpongeBob loves to garden and wants to grow lots of pink flowers for his pal Sandy. He bought a special Flower Power fertilizer to see if will help plants produce more flowers. He plants two plants of the same size in separate containers with the same amount of potting soil. He places one plant in a sunny window and waters it every day with fertilized water. He places the other plant on a shelf in a closet and waters it with plain water every other day.

→ What did SpongeBob do wrong in this experiment? Explain.

SpongeBob did not provide both plants with the same amount of water and sunshine. In order to test the fertilizer correctly, both plants should have been placed in the sunny window and watered every day with the same amount of water. The only difference between the two plants should have been the fertilizer -one plant would be watered with the water with fertilizer and the other would be watered with plain water.

→ What should SpongeBob do to test the effectiveness of Flower Power fertilizer? Write an experiment.

Answers will vary. Experiments should address the problems in SpongeBob's experiment.

◆ Super Snails

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Test Results		
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Terry	72%	70%

→ Based on the data provided, do the Super Snail Snacks work? Explain your answer.

The Super Snail Snacks appear to have worked for Gary and Barry. Both of them increased their test results after eating the snacks for three weeks. Larry did not show any improvement and Terry scored lower on his second test. However, it is difficult to determine if the Super Snail Snacks are an effective way to increase a snail's brain power based on this experiment alone as all the snails ate the snacks (no control group). The gains shown by Gary and Barry may have been due to the Super Snail Snacks, but further testing would be needed to make sure the results were not due to other factors.

◆ **Bubble Time**

Patrick loves bubble gum and would like to be able to blow bigger bubbles than anyone else in Bikini Bottom. To prepare for the Bikini Bottom Big Bubble Contest, he bought five different brands of bubble gum and needs your help to find the brand that creates the biggest bubbles.

→ Write an experiment to test the bubble power of the bubble gum brands and help Patrick win the contest.

Students should make sure to perform the same test with each brand in order to obtain reliable results. Repeated trials would generate more data to analyze and help Patrick pick the best bubble gum brand for the bubble blowing contest.

Extension Idea: Provide an opportunity for the students to try their bubble gum tests!



Scientific Method: M&Ms Lab



INTRODUCTION

In this activity, you will follow the steps of the **scientific method** to discover how many candies of each color are in one bag of M&Ms. It will show you how scientists record **data** on charts, make graphs, and draw **conclusions**. Do not eat any of the candies until you are permitted, because it will affect your results. Do not open the bag until you are instructed to do so.

OBJECTIVES

1. Name and describe the steps of the scientific method.
2. Follow the steps of the scientific method to solve a problem.
3. Record data in a table or chart.
4. Construct a graph that shows the results of the investigation.

DIRECTIONS

1. State the problem: (*Hint – What are you trying to find out?*)

2. Gather information.

What colors of candies are found in these bags?

Which color do you think is most common? _____

3. Form a hypothesis. Write a statement that tells how many candies you think will be in the bag and how many there will be of each color. Remember, the total number of candies must equal the sum of candies of each color.

4. Experiment! Open the bag of candies. **No eating yet!** Sort the candies by color.

5. Record and analyze data.

- a. Write the colors of the candies in the first column of the **data** table.
- b. Count how many candies there are per color. Record the results in the frequency column of the table.
- c. Add the numbers in the frequency column, from the top line to the bottom. Write the total number of candies on the bottom of the

- frequency column where it says "Total".
- d. Determine the percentage that each candy color is of the entire bag, and record it in the percentage column of the table.

$$\text{Percentage} = \frac{\text{\# of candies of one color}}{\text{total \# of candies in the bag}} \times 100$$

Color	Frequency	Percentage
Total		100%

- e. Use the data that you entered to make a bar graph using MS Excel.
- ◆ Label the horizontal axis with the colors of the candies.
 - ◆ Label the vertical axis with the numbers from 1 to 12.
 - ◆ Color the bars the same colors as the candies.
 - ◆ Give your bar graph an appropriate title.
 - ◆ Print your graph and staple it to this handout.

6. Form a conclusion.

- a. On the lines below, form a **paragraph** that answers the problem you looked to solve in the M&M lab.
- b. Your paragraph should include:
- An answer to the question addressed in #1.
 - The total number of candies in your bag and how many there were of each color (frequency).
 - How your actual results compare with your hypothesis.

7. How would you improve this experiment in the future? What would you change about your experimental design?

8. Discuss your findings with the class.



Scientific Inquiry and M&M Lab Grading Rubric



The presentation contains all required information.	10	8	6	4	2	0
The presentation is logically organized.	10	8	6	4	2	0
The explanation of the scientific research is accurate and detailed.	10	8	6	4	2	0
The scientific method was closely followed.	5	4	3	2	1	0
A hypothesis is included in proper if/then format.	5	4	3	2	1	0
A graph is included with proper labels and formatting.	5	4	3	2	1	0
Conclusions discuss the results and include suggestions for improvement.	5	4	3	2	1	0
The presentation is free from grammar, punctuation, capitalization, or spelling mistakes.	5	4	3	2	1	0
Group work is equal and cooperative	5	4	3	2	1	0

Total _____ of 60 points