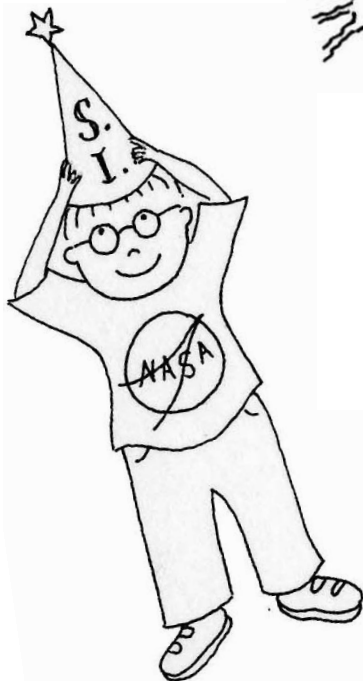


Put on your SI hats!*

* Thinking caps = Scientific Inquiry



science is a question without an answer
for which there is a good chance for a solution.
-unknown



[Teacher Lesson Plan]

Subjects: language arts, science.

Grade Level: 2-5 depending on use of materials and teacher guidance.

Strategy and Activity: 1. readers' theater
2. science experiment using scientific inquiry.

Motivational Materials: *Marsby and the Martian Detectives*.
Book with readers' theater format and CD, 25 minutes.
Optional card game, Go Rover.

Tools: A plastic bottle of spring water.
A thermometer. A freezer. A worksheet handout.

[overview] In this activity, elementary school students experiment to test the hypothesis that Mars was once hotter.

[purpose] Students use scientific inquiry to answer the question, “Was Mars once hotter?”

[objectives] By completing this activity, students will participate in using scientific inquiry skills:

- Ask questions that will be the basis for formulating a hypothesis.
- Formulate a hypothesis.
- Plot data on a number line, make observations, and answer questions that will be the basis of proposing an experiment to test the hypothesis and drawing a conclusion.
- Propose an experiment to test the hypothesis.
- Compare results with the predicted results.
- Draw conclusion. Share results and conclusion with others.

[experiment] The students will test the hypothesis that Mars was once hotter.

Note: Prior to the experiment, using a number line, students will plot the measured temperature of a freezer and NASA’s measurements of the temperatures on the surface of Mars, and compare them.

The students will observe what happens to a plastic bottle of water that is left in the freezer overnight.

Based on this experiment, the students will:

- Discuss what happens to the water.
- Compare the temperature of the freezer with temperatures on Mars.
- Evaluate the hypothesis that the surface of Mars was once hotter.
- Conclude that Mars was once hotter.

Use the process of Scientific Inquiry to answer the question:

How could Mars have been hotter?

(Ask questions. Formulate a hypothesis. Record and observe data. Propose an experiment. Predict results. Discuss actual result/conclusion.)

Possible hypotheses:

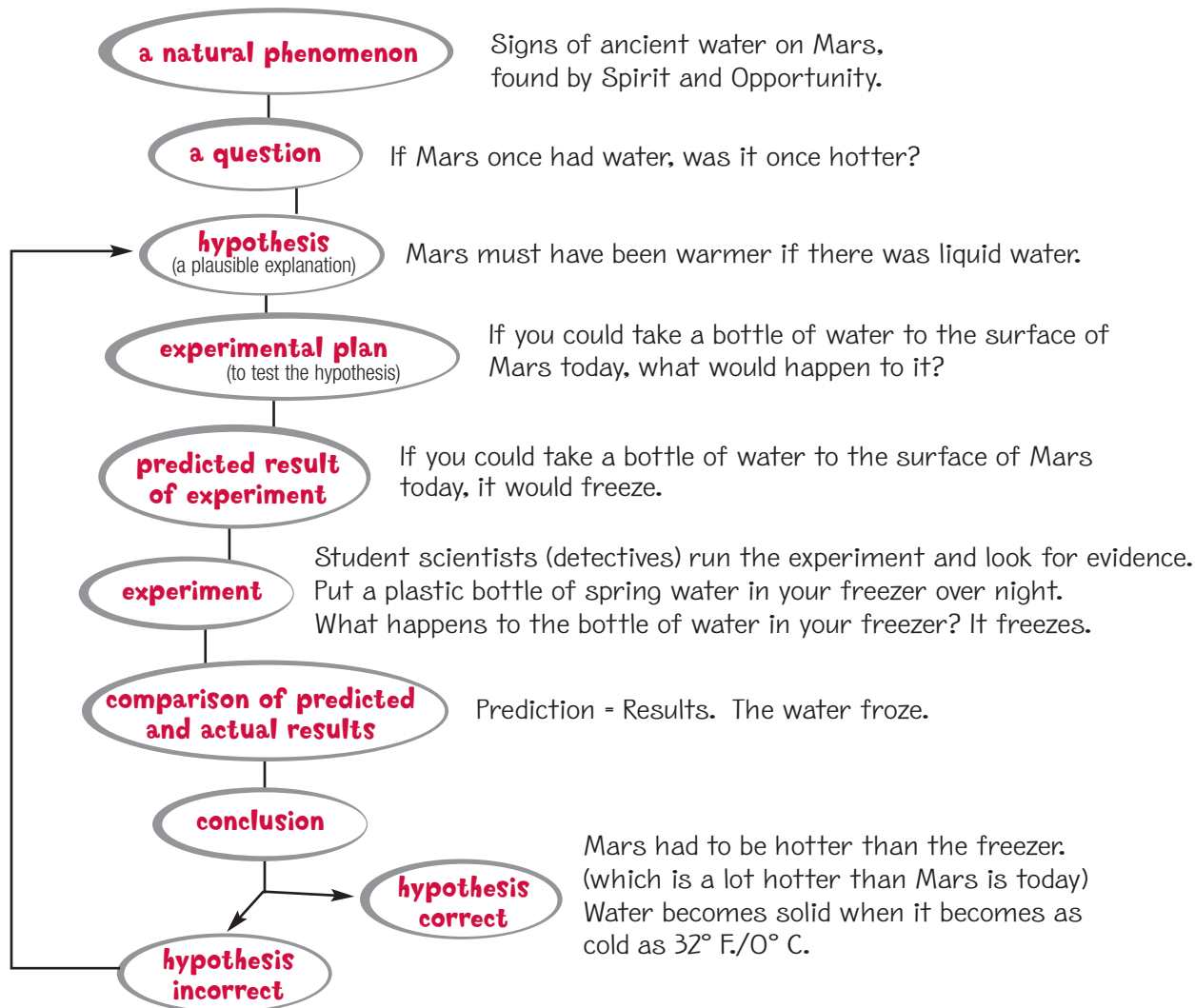
1. The sun could have been hotter.
2. Mars could have been closer to the Sun.
3. It could have been the greenhouse effect of the Martian atmosphere.
4. Mars could have had a molten core and volcanic activity could have raised the temperature of the surface.
5. A meteorite could have crashed into Mars, supplying heat and water temporarily.

[optional]



Simplest Form of SI*

* Scientific Inquiry



Review the process of SI* (develop scientific inquiry skills by asking a question, recording and observing data, formulating a hypothesis, proposing an experiment, predicting results, explaining and communicating the results, and drawing a conclusion)

Scientists ask a question.

What questions did the students ask?

Students formulate hypotheses.

What hypothesis did the students formulate?

Scientists record data. What data did the students record?

Scientists observe with specific tools.

What tools did the students use?

Scientists propose experiments.

What experiment did the students propose?

Scientists make predictions about what they think might happen. What were the students' guesses?

Scientists use their evidence and data to answer their question.

How did students use their evidence and data to answer their question?

Scientists share their evidence and data. How did students communicate the results and share their evidence?

Scientists share their evidence and data. How did students communicate the results and share their evidence?

What would the students do differently if they repeated their investigation? Do the students think scientists repeat their investigations, and if so, why? (Scientists repeat their investigations, based on the results. Some scientists study the same question for many years.)

Activity:

Experiment To Test The Hypothesis: Mars Was Once Hotter.

To The Teacher:

Hint: Use TV cooking show technique. Put a bottle of spring water in the freezer overnight. (the day before the lesson) **Goal:** Finish the lesson in one day. (optional. Depending on grade level, a student may take more responsibility in formulating and running the experiment.)

Motivational strategy for Scientific Inquiry lesson: Readers' Theater activity.

Motivational materials: *Marsby and the Martian Detectives*, (a book documenting the landing and mission of the Mars Exploration Rovers) and companion CD.

Lesson format: Readers' Theater activity. Divide the class into groups. Students read Marsby character parts or listen to the companion CD. (25 minutes)

Tools for Scientific Inquiry lesson:

A plastic bottle of spring water. A thermometer.

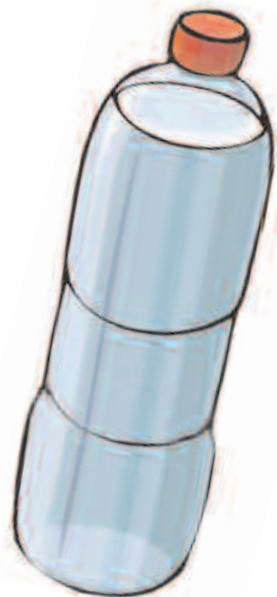
A freezer. A thermometer number line worksheet handout.

Fact: The Mars Exploration Rovers, Spirit and Opportunity, found signs of ancient water in 2004. Mars must once have been hotter. (It would have been ice if it were not warmer.)

Using the process of scientific inquiry, the students will plot data on a thermometer number line and do a simple experiment to test and prove the hypothesis that Mars was once hotter.

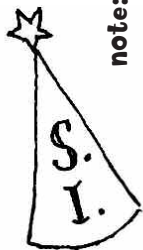
From a list of measurements given on the worksheet handout, the students will plot the measured temperature of a freezer and measurements of temperatures on the surface of Mars on their thermometer graphic. (This hands-on activity is important in the understanding of how measurement data can be organized to run an experiment that tests a hypothesis.)

Then the students will run an experiment by observing what happens to a bottle of spring water left in the freezer overnight. If the water freezes at a temperature warmer than the surface of Mars, they will have shown that water is frozen on the surface of Mars, and can conclude that if there were ancient water on the surface of Mars then the surface of Mars would have to have been hotter.



Teacher/Student Dialogue

note: Teacher should guide the dialogue until there is an appropriate **Answer** for each **Question**.



To The Students:

Marsby gives us a feel for the surface temperature of Mars when he asks Mission Control to send some friends for the summer. “While my polar ice cap is evaporating,” he says. It’s cold enough in the summer as it is”. Later he asks, “Was I once hotter? Did I have water?”

You are scientists. Scientists are detectives. Scientists ask and find out the answers to mystery questions.

You will be involved in an experiment to test the hypothesis that Mars was once hotter. That is the mystery question that Marsby asks. “Was I once hotter?”

- Q.** What do you have in your house that is cold? **A.** Freezer
- Q.** What do you have in your house that is hot? **A.** Cooking stove. Hot shower.
- Q.** Marsby is complaining that he is cold. How cold do you think he is?
A. He is wearing a wool scarf and he looks like he is freezing.
- Q.** Have you ever felt like you were freezing?
A. Probability is yes. Probably going to the snow.
- Q.** What did you do to warm up? **A.** Sat by the fireplace. Drank hot chocolate.
- Q.** What do you think would happen if one of your grandchildren becomes an astronaut and is able to go to Mars and could take a cup of hot chocolate to Marsby. Especially if Marsby saves some for later. **A.** It would freeze.
- Q.** Of course the hot chocolate is a little iffy but what do you think would happen if you could take a bottle of spring water to Mars? **A.** Maybe the water would freeze.
- Q.** We can’t go to Mars to check but we can try to run an experiment with something we have on Earth, like your freezer. Is your freezer as cold as the surface of Mars?
A. Maybe. Don’t know for sure. No way of knowing.
- Q.** At least my ice cream isn’t melting. Is your ice cream melting? **A.** No
- Q.** We need more information, more data, to find out. Would measuring the temperature of the freezer and comparing it to Mars be a good way?
A. OK. We should measure the temperature of the freezer and compare it with the temperature of Mars.
- Q.** This is where asking an expert comes in. Like a scientist. Or like a teacher who has already gotten the information from the Internet and could share the information with you. Or use a thermometer to measure the temperature yourselves. I’m sure you know what an iPod is. But who knows what a thermometer is?
A. A thermometer is a tool that will measure temperature.

Note to teacher: Time out to plot a number line. Give out copies of the thermometer number line worksheet handout for the students to record data by plotting points on the thermometer graphic.

Teacher/Student Dialogue, cont.

note: Teacher should guide the dialogue until there is an appropriate **Answer** for each **Question**.

Note to students: This is a good time to record some data on your thermometer number line. You will find a list of temperatures on your worksheet handout. First: Record temperatures on Earth. Second: Record what scientists know about the temperatures on the surface of Mars.

- Q.** Based on the data on your number line, we will run an experiment to test our hypothesis that Mars was once hotter. First, looking at the number line, is the temperature of the freezer warmer than the surface temperature of Mars?
- A.** Yes, the number line tells us that the temperature of the freezer is warmer than the surface temperature of Mars.
- Q.** So, is it fair to say that if water freezes in the freezer, it will freeze on the surface of Mars? **A.** Yes
- Q.** What experiment can we run to show that water will freeze on the surface of Mars?
- A.** We could put a plastic bottle of spring water in the freezer overnight, and see what happens.
- Q.** Ah ha. Good thinking! Can you predict what will happen to the water?
- A.** It will freeze.
- Q.** I just happened to play the TV cooking show game and put a plastic bottle of water in the freezer overnight (let's get the bottle out of the freezer.) What actually happened to the bottle of water in the freezer? **A.** It froze.
- Q.** What do your results tell us would happen to water on the surface of Mars?
- A.** The temperature on the surface of Mars today is (as cold as/colder) than the temperature of the freezer. Therefore, any water on the surface of Mars is frozen.
- Q.** What do we call water that is frozen? **A.** Ice
- Q.** What do we have to do with ice to make it water? **A.** Make it hotter.
- Q.** Since the Rovers found signs of ancient water on Mars, what is your conclusion about the temperature of the surface of ancient Mars?
- A.** Mars must have been hotter than it is today. Mars had to be warmer than the freezer. The temperature on the surface of ancient Mars must have been more like the refrigerator. (Refrigerator: 32-40° F.) To have liquid water, Mars had to have been hotter!

To the students:

You started with a hypothesis, you recorded data, you made a prediction, you ran an experiment, you confirmed the prediction, you communicated your results.

Congratulations on your work as scientists.



Name: _____

Date: _____

Using the greater than/less than number line:

Plot the following temperatures on your thermometer diagram, in Fahrenheit and Celsius, and connect each point with its letter code A-G. Follow Example Code A.

First: Record temperatures on Earth.

- The room temperature. **A)** 72°F or 22°C
 A hot summer day on Earth. **B)** 100°F or 40°C
 The boiling point of water. **C)** 212°F or 100°C
 The temperature of the freezer. **D)** 20°F to 30°F or -1°C to -6°C

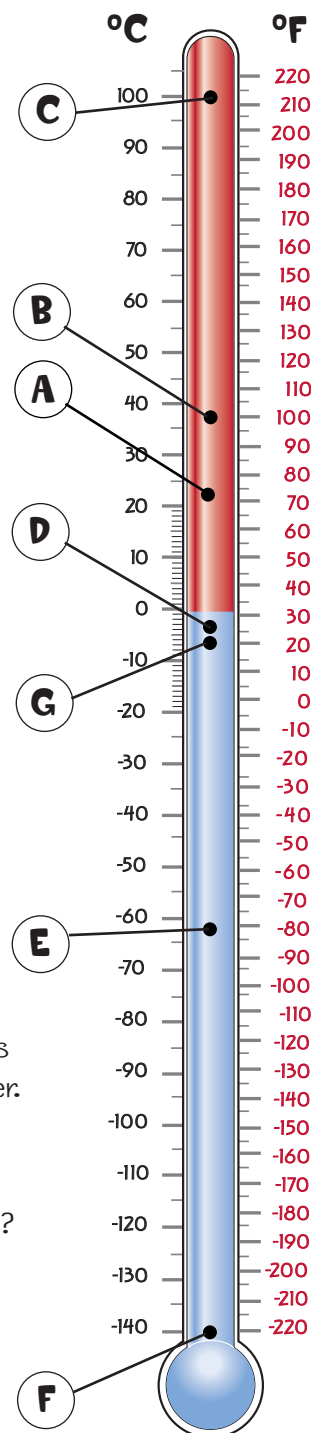
Second: Record what scientists know about the temperatures on the surface of Mars

- Mean surface temperature. **E)** -81°F or -63°C
 Minimum surface temperature. **F)** -220°F or -140°C
 Maximum surface temperature. **G)** 20°F or -6°C

Observation

Based on the data on your thermometer number line, compare the temperature of Mars with the temperature of the freezer.

- Q.** Is the temperature of the freezer warmer than the surface temperature of Mars? **A.** Yes
- Q.** If water freezes in the freezer, is it fair to say, it will freeze on the surface of Mars? **A.** Yes
- Q.** What experiment can we run to show that water will freeze on the surface of Mars? **A.** Put water in the freezer and if it freezes, it will freeze on the surface of Mars.
- Q.** What actually happened? **A.** It froze.
- Q.** What do the results tell us would happen to water on the surface of Mars? **A.** The temperature on the surface of Mars today is (as cold as/colder) than the temperature of the freezer. Therefore, any water on the surface of Mars is frozen.)
- Q.** Since the Rovers found signs of ancient water, what does that tell you about the temperature of the surface of ancient Mars?
A. Mars must have been hotter.
- Q.** What is your conclusion? **A.** Mars had to have been hotter than the freezer if Mars had ancient water.



[Bonus Question] Using your number line, can you give the exact temperature at which water freezes?

Name: _____

Date: _____

Using the greater than/less than number line:

Plot the following temperatures on your thermometer diagram, in Fahrenheit and Celsius, and connect each point with its letter code A-G. Follow Example Code A.

First: Record temperatures on Earth.

- The room temperature. **A)** 72°F or 22°C
- A hot summer day on Earth. **B)** 100°F or 40°C
- The boiling point of water. **C)** 212°F or 100°C
- The temperature of the freezer. **D)** 20°F to 30°F or -1°C to -6°C

Second: Record what scientists know about the temperatures on the surface of Mars

- Mean surface temperature. **E)** -81°F or -63°C
- Minimum surface temperature. **F)** -220°F or -140°C
- Maximum surface temperature. **G)** 20°F or -6°C

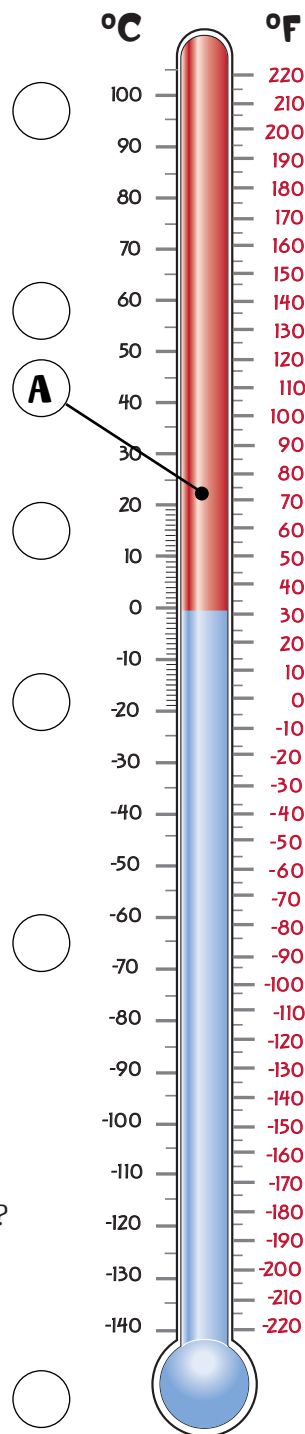
Observation

Based on the data on your thermometer number line, compare the temperature of Mars with the temperature of the freezer.

- Q.** Is the temperature of the freezer warmer than the surface temperature of Mars? **A.** _____
- Q.** If water freezes in the freezer, is it fair to say, it will freeze on the surface of Mars? **A.** _____
- Q.** What experiment can we run to show that water will freeze on the surface of Mars? **A.** _____

- Q.** What actually happened? **A.** _____
- Q.** What do the results tell us would happen to water on the surface of Mars? **A.** _____

- Q.** Since the Rovers found signs of ancient water, what does that tell you about the temperature of the surface of ancient Mars?
A. _____
- Q.** What is your conclusion? **A.** _____



[Bonus Question] Using your number line, can you give the exact temperature at which water freezes?