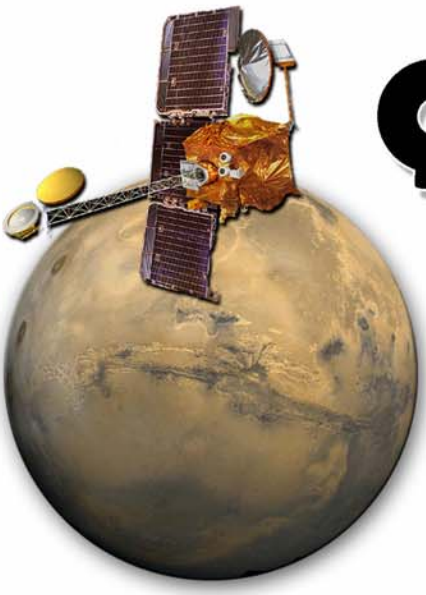
Arizona State University

National Aeronautics and Space Administration



Question Mars

An Introduction to the Process of Science

An inquiry-based, critical thinking lesson as an introduction to the process of science.

STUDENT GUIDE

Question Mars

An Introduction to the Process of Science

Objective: Create a question about Mars that can be answered using images taken from orbit.

Student Introduction:
All science begins with a question. That is the foundation of this activity. The process of science begins with what some people refer to as the "scientific method". We learn and practice this in our classrooms. This process can start from questions we create based on our curiosity. Professional scientists have questions about Mars they want to answer, and so will you as you start to investigate images from our neighboring planet. As you go through the process of science as it relates to this activity, it is important for you to:

- Think about what you are curious about related to Mars and create general questions
- Evaluate your questions making sure you have appropriate tools to answer those questions
- Realize that science is most often conducted in small bits and pieces. It's understandable to have "big picture" questions, but scientists (and you) need a specific focus/question of study. This will contribute to a greater understanding about Mars through detailed research.

There are many images available of Mars. Over the past 30 years, NASA has sent landers, rovers and orbiters to image the surface of Mars. This activity will focus on images that have been taken from orbit. The Mars Odyssey spacecraft has been orbiting Mars since 2001. One of the tools it uses to take images of Mars is the Thermal Emission Imaging System (THEMIS). THEMIS has taken thousands of images of Mars that are available on the Internet (http://themis.asu.edu).

THEMIS (pictured on the left) is a two-in-one camera system:

- Visible Imaging System:
  - Shows the morphology or shape of the surface
- Infrared Imaging System:
  - Can tell us the temperature of the surface (daytime and nighttime)
  - Provides information about what materials on the surface are made of
  - Daytime infrared images also show the morphology or shape of the surface in much the same way visible images do.

As you gather observations, you should try to focus on and examine visible images. If you do decide to examine infrared images, just be sure to focus on the shapes (morphology) of the surface features you see.

All science begins with a question and continues with observations and the development of possible hypotheses based on your initial observations. Keep in mind that it is a natural part of science to refine or even change your question as you research. The process of science continues with designing an experiment of how to answer that question and test your hypotheses. For this activity, the focus is on coming up with a question to research using the THEMIS camera as your primary tool or data set. This is not necessarily an easy task, but through making observations and looking for patterns, it should be fun!

Student Worksheet 1

Establishing a Research Topic

Name(s) _____

Date _____

1. Within your group, brainstorm four general topics that can be studied about Mars:

_____ _____

_____ _____

2. After a class discussion, list six major categories of topics the class can choose to study about Mars:

_____ _____

_____ _____

_____ _____

3. List the topic your group will research: _____

Brainstorming Questions

List five questions you are curious about based on your topic and how it may relate to Mars:

Question 1: _____

_____

Question 2: _____

_____

Question 3: _____

_____

Question 4: _____

_____

Question 5: _____

_____

Student Worksheet 2

Making Observations of THEMIS Images

Name(s) _____

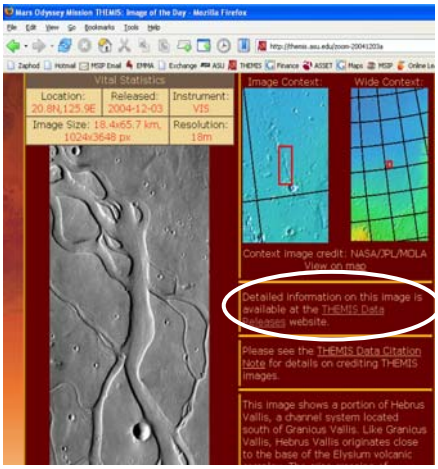
Date _____

This activity will focus on images that have been taken from orbit by the Thermal Emission Imaging System (THEMIS) onboard the Mars Odyssey spacecraft. These images of Mars show great detail of many of the geologic features seen on the surface of Mars from orbit. In this exercise, you will look at THEMIS images and log specific information about each image you observe. Here's what to do:

1. Go to the **http://themis.asu.edu/topic** website and click on the thumbnail (small square showing a part of a THEMIS image) of the topic your group will research:

2. Click on any of the thumbnails to see a THEMIS image of Mars related to your topic:
   - There are six large thumbnails at the top of the page.
   - Below the top six thumbnails are more thumbnails of additional images.
   - There are generally multiple pages of image thumbnails to choose from.

3. Click on a thumbnail to see a specific THEMIS image, context images showing the area where the image is located on Mars, and general information about the image.
   - You can get an enlarged view of the THEMIS or context images by clicking on the image.
   - To get the Image Identification Number click on the THEMIS Data Releases link.
     - This will open a new window showing the Image ID # and image information
     - Images that are not yet released will not have this link.



Student Worksheet 2 (continued)

4. Log the information on the observation tables. Make observations of a minimum of four images. The more images you can observe, the more easily you can look for patterns. Log the following:

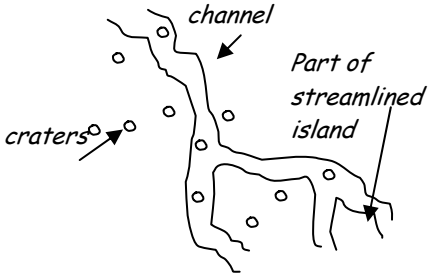
    a. Surface/Geologic Feature(s) Observed: Name the **specific** surface/geologic features you find interesting in each image. Look for patterns or for the same surface/geologic features in multiple images. Be sure to include those same features in your table multiple times. This will help you remember how a particular feature looks the same (or different) in multiple images – very valuable information! To help you correctly name surface/geologic features, use the **Feature Identification Charts**.

    b. Image ID Number: If the image has the THEMIS Data Releases link, click on it to find the image identification number. If not, write the title of this image and/or the page, column, and row number to possibly relocate it.

    c. Sketch the Geologic Feature(s): Make a sketch or drawing of the portion of the THEMIS image that shows the feature(s) you are observing. Do not sketch the entire image.

    d. Specific Observations of Geologic Feature(s): Write down specific observations of the feature(s) you sketched. Consider patterns you may look for with these features in other images.

Here's an example of how you can fill out the observation table:

Surface/Geologic Feature(s) Observed & Image ID #	Sketch of Surface/Geologic Feature(s)	Specific Observations of Surface/Geologic Feature(s)
Channel with craters **Image ID #:** V11030007		*-Channel does not seem very wide* *-Can see streamlined islands* *-Small craters both on the outside and inside of channel* *-All craters in image seem to be about the same size*

Student Worksheet 2

Making Observations of THEMIS Images

Surface/Geologic Feature(s) Observed & Image ID #	Sketch of Surface/Geologic Feature(s)	Specific Observations of Surface/Geologic Feature(s)
Image ID #:		
Image ID #:		
Image ID #:		
Image ID #:		

Student Worksheet 2

Making Observations of THEMIS Images

Surface/Geologic Feature(s) Observed & Image ID #	Sketch of Surface/Geologic Feature(s)	Specific Observations of Surface/Geologic Feature(s)
Image ID #:		
Image ID #:		
Image ID #:		
Image ID #:		

Student Worksheet 3

Question Development – Refining Questions

Name(s) _____

Date _____

After making your observations of the different surface/geologic features, you should now have a better idea of what types of questions can be answered using THEMIS images. Keep in mind that ALL questions are good questions! Anything you are curious about is a valid question! For any science experiment, however, your question should be answerable by using the tools you have available. Your primary tool are images taken by the THEMIS camera.

In order to be sure you have the best question possible for your team to research, you will go through three steps.

- STEP ONE: Create three new questions, stating the geologic features that will be the focus of your question.
- STEP TWO: Evaluate each of your new questions with a set of criteria.
- STEP THREE: Discuss and debate with your teammates to finalize the science question you will focus your research on.

STEP ONE:
Create three new questions that focus on specific geologic feature(s) you have observed. Important points to think about are:

- Focus on Identified Surface/Geologic Features: Look at your *THEMIS Observation Tables*. Choose a **feature or combination of features** (sand dunes, lava flows, lava tubes, etc.) you were able to identify in one or more THEMIS image as the focus of your question.
- Try to focus on **size(s)** or **shape(s)** or **where a feature may form**.
- Key Question Words: Some suggested key words you may consider using are: evidence, size, shape, similarities, differences, relationships, patterns, distribution. Here are a few examples of possible questions:
  - Is there a relationship between _____ and _____?
  - What is the size range of _____?
  - Where do _____ occur on or around _____?

Here are two examples:

Example 1: Name of Surface Feature: Lava tubes

Sample Question: How wide are different lava tubes on Mars?

Example 2: Name of Surface Feature: Dunes and craters

Sample Question: Is there a relationship between crater size and evidence of sand dunes?

Create your new questions on the next page:

Student Worksheet 3 (continued)

Name of Surface Feature(s):_____

Question 1: _____

_____

Name of Surface Feature(s):_____

Question 2: _____

_____

Name of Surface Feature(s):_____

Question 3: _____

_____

STEP TWO:
Look at the three new questions you just created. Evaluate your questions by using the checklist below. If you can check (√) most, or all of the red and blue boxes, your question should be good enough for your team to consider as the focus for your research.

Remember, all questions are good questions! It is important, however to be sure you are asking a question that can be answered with the tools you have available – in this case, the THEMIS camera.

Questions		
1	**2**	**3**

Question can be answered by images taken by the THEMIS camera.

Question includes the name(s) of the surface geologic feature(s) you want to study.

Question focuses on one or more of the following aspects of geologic features:

Size(s) ☐ Shape(s) ☐ Where features form ☐ _____(other) ☐

Question **does not** focus on **HOW** features form.

Question includes one of the following words: evidence, size, shape, similarities, differences, relationships, patterns, or _____

Decide which one of your questions would be the best potential question for your team to research.

Potential Science Question: _____

_____

Student Worksheet 3 (continued)

STEP THREE:
After discussing and debating your potential questions within a group, now as a whole **TEAM**, decide which final question is the most interesting and answerable question using THEMIS images. Try not to feel "possessive" of your own created question. Your creation and participation in the team discussions and decisions will help your team select the best and most interesting question to focus on for your research.

Write your team's final science question in the box below.

Final Team Science Question: _____

_____

Make sure your final question meets the criteria. If you can check (√) most, or all of the red and blue boxes, your question should be good enough for your team to use as the focus for your research.

- ☐ Question can be answered by images taken by the THEMIS camera.
- ☐ Question includes the name(s) of the surface geologic feature(s) you want to study.
- ☐ Question focuses on one or more of the following aspects of geologic features:
  Size(s) ☐ Shape(s) ☐ Where features form ☐ _____(other) ☐
- ☐ Question **does not** focus on **HOW** features form.
- ☐ Question includes one of the following words: evidence, size, shape, similarities, differences, relationships, patterns, or _____

Student Worksheet 4

Experiment Design and Hypothesis Development

Name(s) _____

Date _____

For this exercise you will focus on one particular question that you refined in the last exercise. You will create a plan (an experiment design) of how you would go about answering that question using THEMIS images. Additionally, you will develop a set of working hypotheses (possible answers to your question) and consider how you would go about testing those hypotheses.

Science Question:_____

_____

1. What specific feature(s) do you need to have in a THEMIS image to answer this question?

2. What regions of Mars would you go to in order to find images that would help you answer this question? (You can either name regions of Mars or describe what type of regions you would look for.)

3. How many images of Mars do you think would be necessary to realistically and sufficiently answer your question?

   1 5 - 10 20 - 40 60 - 80 100+

   Please explain:

4. Do you need to make any measurements to answer your question? If yes, what measurements need to be made?

Student Worksheet 4 (continued)

5. Based on your current observations, list at least one possible outcome to the answer to your question? (This will become your working hypothesis.) Include what observations you have already made that lead you to formulate your hypothesis.

   Hypothesis Example for the question "Is there a relationship between crater size and sand dunes?": *Craters larger than ~18 km will more likely have sand dunes than smaller craters.*

   Current observations that support this hypothesis: *Within our group we observed sand dunes in about five images that had craters wider than the THEMIS image width. There were no smaller craters that had sand dunes. Since THEMIS images are 18 km wide, we believe that we may find that craters larger than ~18 km will most often have sand dunes.*

   Look at the observations you and your group have made of images relating to your topic. Based on those preliminary observations, list your group's current working hypothesis below:

   Hypothesis:

   Current observations that support this hypothesis:

6. In science, experiments need to be designed so they are "repeatable". "Repeatable" means that other scientists could conduct the ***same*** experiment with the ***same*** images and follow the ***same*** step-by-step procedure and get the ***same*** results. This would validate your results.

   Let's pretend that you actually gathered the data from questions #1-4 in this section in order to answer your science question and test your hypothesis. That information would be:

   - Images that contain _____ (name the geologic feature you are looking for)
   - Images in regions of Mars such as _____
   - _____ # of images to answer the question and support or refute your hypothesis
   - Measurements of _____ (list what measurements, if any)

   Would this be enough information to have your experiment be repeatable? If yes, please explain. If no, what other information might you need to obtain to make your experiment repeatable by any scientist?

Student Worksheet 5

Experiment Design – Refining Your Experiment

Name(s) _____

Date _____

When designing an experiment to answer a question and support or refute a hypothesis, your experiment needs to be repeatable. If any scientist conducts your same experiment, they should be able to obtain the same results. This is what helps validate the science you have conducted. In order for your experiment to be repeatable, you need to be able to describe, in as much detail as possible, the step-by-step plan and the exact information you would gather from each and every image you observe.

To do this, think about specific information (including details from the previous questions) you would need to record from each image you observe, and what steps you would take to obtain data towards answering your question. It is important to think about why each step would be important in your process.

Here's how you may consider starting your list of steps:

1. First, I would go to the http://themis.asu.edu *topic page** website to find images to observe. For my project I would look at images relating to _____ (*list what topic/feature you are focusing on)*.
   (*Think about whether you would use the topic page or the map tool.)

2. For each image I observe, I would write down the **Image Identification number** (the V#) so that I (or other scientists) could reexamine those same images at any time.

3. For each image I observe, I would also write down whether it had (or didn't have) the specific feature/s in the image that I am looking for. Even if the image does not have the feature that I am looking for, that is still valuable data. The specific feature/s I would be looking for are: _____ *(list the specific geologic features you are looking for).*

4. Next, I would record the _____ **and** _____ of each image to look for any patterns in the observations I make and also to be able to plot that information on a map.

Continue this list or start a new list that describes how you would go about gathering data to test your hypotheses and help answer your question. (Use additional paper as necessary.)

NOTES

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An Introduction to the Process of Science

http://marsed.asu.edu
http://msip.asu.edu