



Question Mars:

An Introduction to the Process of Science

Goal:

This activity will guide students through an inquiry-based lesson introducing them to the process of science or what many also be referred to as the “scientific method”. The foundation of this activity is the development of testable scientific questions. It includes having students evaluate their questions ensuring they use an appropriate tool to answer those questions. Additionally, it should assist students in understanding how science really works. Scientists ask questions and conduct their studies in small bits and pieces, which can contribute to a greater understanding. This series of exercises will lead students from the formation of general “big-picture” questions about Mars towards focused and refined questions that can be answered using actual orbital images of Mars.

Grade Level:

3-12, adjust activity to meet class needs

Time Requirements:

2 - 4 class periods

Objectives:

Students will:

- Discuss topics and features that can be studied about Mars
- Create scientific questions
- Make observations of images of Mars
- Refine scientific questions
- Develop an experiment design and set of working and testable hypotheses

Materials:

This activity is designed to be implemented with students in groups of two or more, depending upon the number of computers you have available. If you do not have computers available, you can print out THEMIS images categorized by topic on 8½ X 11” paper, or request to borrow image sets from the ASU Mars Education program.

- Question Mars Student Worksheets I, II, III, and IV (For elementary groups only worksheets I, II and III.) **Please note that there are two versions of the Question Mars Student Worksheet III** – one for elementary grade level students and one for secondary students. This is indicated at the top of each respective Worksheet III.
- Access to the THEMIS website (<http://themis.asu.edu/topic>) **OR** printouts of the THEMIS images categorized by topic for each group
- Set of Feature ID Charts
- Optional: For upper level students actually designing an experiment, you may consider using the Question Mars Student Worksheet V

National Science Standards:

CONTENT STANDARD A: Science as Inquiry

CONTENT STANDARD D: Earth and Space Science

CONTENT STANDARD E: Science and Technology

CONTENT STANDARD G: History and Nature of Science



Question Mars:

An Introduction to the Process of Science

Teacher Introduction:

All science begins with a question. That is the foundation of this activity. The beginnings of the process of science or what some people refer to as the “scientific method” that we teach in our classrooms stem from questions we create based on our curiosity about something. Students and scientists alike have questions about Mars they want to answer. As students go through the process of science, it is important for them to:

- Evaluate their questions making sure they have an appropriate tool to answer that question
- Realize that science is most often conducted in small bits and pieces which contributes to a greater understanding about a topic

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 is a two-in-one camera system:

- Visible Imaging System:
 - Shows the morphology or shape of the surface
- Infrared Imaging System:
 - Shows the temperature of the surface (daytime and nighttime)
 - Can tell us about what the materials on the surface are made of
 - Daytime infrared images also show the morphology or shape of the surface

As students gather observations, they may examine visible or infrared images, focusing on the shapes (morphology) of the surface features they see.

All science begins with a question and continues with hypothesis development and designing an experiment of how to answer that question and test their hypotheses. Towards the end of the activity, students will be asked to think about testable hypotheses and to begin thinking of a plan (experiment design) to answer their refined science question. This activity by no means takes students through the entire scientific method – although it begins as all science does – with a question.

Procedure:

This lesson can be broken into four main parts. (For elementary groups, it is recommended that you have students work through the first three parts of the lesson only, using Question Mars Worksheets I, II and III. Note: There is a Worksheet III for elementary grade level students and a different one for secondary students).

Part 1: Establishing a Research Topic and Brainstorming Questions (Student Worksheet I)

1. In groups of two or more, have students think about Mars and brainstorm topics or features they could study. Have them write down at least four topics on the Question Mars Student Worksheet I: *Establishing a Research Topic*.

2. Discuss the topics with the entire class and list them out on the board (optional).
3. Acknowledge student contributions and announce that many of the topics and features they have mentioned fall into six main categories. These six main categories are:
 - Canyons
 - Channels
 - Craters
 - Dunes
 - Volcanoes
 - Wind or Dust

Keep in mind that some of the student contributions may not fit into one of these categories as there are many more you can study about Mars. In order to complete the rest of the lesson, it is recommended you focus only on the above listed general topics.

4. Depending on your student/computer ratio (or image hand-out sets), group students accordingly (ideally in groups of two) and have a member of the group pick out one of the pre-determined topics (see the topic cards resource sheet) from a “hat”. This will become the topic their group will research. Have students write down their topic on their Worksheet I. If you wish, you can have student groups select which topic *they* would like to focus on for the rest of the activity.
5. Using the *Brainstorming Questions* section of Worksheet I, student groups should create up to five questions they have about their topic and how it may relate to Mars. Student questions at this point can focus on any aspect of their topic and Mars they are curious about. Any question student groups write is acceptable, as long as it is in the form of a question. Question development is the most important aspect of this exercise.

Part II: Making Observations of THEMIS Images (Student Worksheet II)

1. Using the Question Mars Student Worksheet II: *Making Observations of THEMIS Images*, go over the procedure of what to do as listed on the worksheet with the students. You may want to demonstrate an example with them.

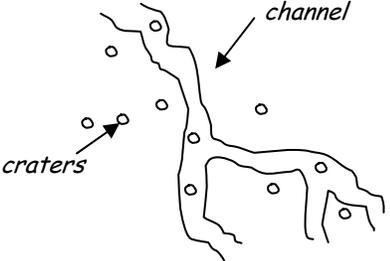
Note: If computer access is not available, you can print out the image sets provided as a resource as part of this lesson.

2. When filling out the Student Worksheet II: *Making Observations of THEMIS Images*, students should use the **Feature ID Charts** provided to identify and name specific surface/geologic features they can see in each THEMIS image. For each THEMIS image they observe students should:
 - Name at least one specific surface/geologic feature (or combination of features) they can see in a portion of an image that looks interesting – students should not write down the name of the image that may be shown on the page, but should name the surface/geologic feature (for example: dunes, craters, channels, etc.).
 - Draw a sketch of the feature(s) - students do not need to sketch the entire image, just the portion of the image where they see the feature(s) that catch their attention
 - Describe their observations of that feature(s) – bulleted statements rather than full sentences are encouraged. Students should try to look for patterns when they make their observations.

Students should keep in mind that surface/geologic features listed in the categorized Feature ID Charts are general features commonly associated with that specified theme. Many features listed on the Feature ID Charts can be associated with multiple themes or topics. Using multiple Feature ID Charts is encouraged.

For example, lava flows and lava tubes can often be associated with the topic of volcanoes and are on the “Features Often Associated with Volcanoes” Feature ID Chart; however, you may see craters in “volcano” images as well. Craters are not on the “Volcanoes Feature ID Chart”, so students may want to refer to multiple Feature ID Charts.

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

Name of Surface/Geologic Feature(s) Observed	Sketch of Surface/Geologic Feature(s)	Specific Observations of Surface/Geologic Feature(s)
<i>Channel with craters</i>		<ul style="list-style-type: none"> -Channel does not seem very wide -Channel branches off in places -Small craters both on the outside and inside of channel

It is recommended that students make at least 4 observations of features in THEMIS images. If they can make more than 4 observations, use the additional observation tables or make extra copies as necessary. As students begin looking at images, it will be very easy for them to look at one image for a long period of time. Encourage students to take a maximum of 5-10 minutes to look at each image. They do not need to understand all that is going on in a particular image; they should just focus on making observations.

Part III: Question Development - Refining Questions (Student Worksheet III Secondary Grade Level) (Recommended for upper elementary and secondary students)

1. Once students have filled out their observation table, have them reexamine the original five questions they wrote down on Student Worksheet I. Have students determine whether or not they would be able to answer any of their original five questions using observations made of THEMIS images. Reassure students that even if they can not answer their original questions using THEMIS images, their questions were still valid. This exercise asks students to evaluate if they can answer their original questions using the THEMIS images as the tool. Students do not need to actually answer these questions. They would just circle (or identify) *Yes* or *No* or *Not Sure*.

Here’s an example of how students would fill out this section:

Question 1: *Yes* *No* *Not Sure*

2. The goal of this next step is to refine student questions so that the observations they have, or can make, of a THEMIS image will enable them to answer their new and refined questions. The specific features observed should be the driving focus of their newly refined questions.

Here are some examples of questions students may create using key words or phrases that are suggested on the Question Mars Student Worksheet III: *Question Development – Refining Questions*: (Observable surface features are indicated in bold print)

- Is there a relationship between _____ and _____?
(Is there a relationship between **crater size** and evidence of **sand dunes**?)
- Where do _____ occur on or around _____?
(Where do **lava tubes** occur on or around volcanoes?)
- What is the size range of _____?
(What is the size range of **wind streaks** on Mars?
(What is the size range of **lava tubes** around Olympus Mons?)

Remember: This is something students can answer by making observations of images. Questions like “Where does lava come from?” is not answerable by making observations of an image.

Have students create their list of three refined questions based on:

- a. Their research topic
- b. Features they observed and logged on their Observation table
- c. Key words or phrases listed (keep in mind only a few examples of key words and phrases are listed. Students can create questions that include the other key words not listed.)

Part III: Question Development - Refining Questions (Student Worksheet III *Elementary Grade Level*)

Once students have filled out their Observation table, the older students are asked to evaluate if their original questions are answerable using THEMIS images as the tool. As this requires a higher level of thinking, younger students, for this exercise will be asked to simply ask new questions that have a refined focus on features they have seen and logged into their Observation tables. In order to help younger students focus, they should:

- a. Look at their observation table and **name a surface/geologic feature** they identified
- b. Create a question that asks about the **shape(s), size(s) or where** this feature may form. These types of questions can be answered by looking at images of Mars, which is the goal of this exercise. These are not the only characteristics students can focus on, but should be very understandable and concrete suggestions of the type of questions that can be answered by looking at images.

Here are two examples that are also provided on the student handout:

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

Sample Question: Are dunes always found in the bottoms of craters?

Part IV: Experiment Design and Hypothesis Development (Student Worksheet IV)

(Recommended for upper elementary and secondary students)

1. Once students have created three **refined** questions, in their groups, have them choose the one they feel is **best** answered using THEMIS images. Students should write this question down on the Question Mars Students Worksheet IV: *Experiment Design and Hypothesis Development*.
2. In this part of the activity, students will consider various aspects of putting together a plan (an experiment design) to help them answer their refined science question.

Here's an example of how students would fill out this worksheet:

Science Question: *Where do lava tubes occur on or around volcanoes?*

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

Lava tubes

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.)

I would look for images near any of the volcanoes on Mars.

or

I would look for images near the Elysium Mons volcano.

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: *Answers may vary – but would include a thought out explanation of how many images they would need to sufficiently answer their question. A sample answer may be:*

We think we would need about 20 images so that we could look at a few images all around a volcano.

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

No measurements need to be made

5. Based on your current observations, list three possible outcomes to the answer to your question? (These will become your three working hypotheses)

Note: Students can form their hypotheses on one of two levels:

-Basic level: One that is a statement that has no connection to the process of how something works (hypothesis a)

-Advanced level: One that provides link to something or an indication of process (hypothesis b or c)

- a. *Lava tubes will be found to the north of a volcano*
 - b. *Lava tubes will be found on the side of a volcano where you have the lowest elevation*
 - c. *Lava tubes will be found on all sides of a volcano, because...*
6. In science, experiments need to be designed so they are repeatable. This allows others to conduct the experiment following the same step-by-step procedure to get the same 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 hypotheses. Would that 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?

I don't think this would be enough information because scientists would have no way of knowing how to find the same images I looked at without some sort of identification number. They would probably also at least need to know the latitude and longitude of the images I was looking at to see where they were in relation to a volcano.

Part V: Experiment Design – Refining Your Experiment (Student Worksheet V) - OPTIONAL
(Recommended for upper elementary and secondary students who want to actually conduct their experiment.)

This section actually gives students a hint as to some of the essential information they will need to acquire from each and every image they look at. There will be other information they should consider logging as well, but this gives them a step-by-step start.

Here are the steps provided on Student Worksheet V with some brief explanations:

1. First I would go to the <http://themis.asu.edu> *topic page** website to find images I could make observations of that pertain to my question and hypotheses. For my project I would look at images relating to ___volcanoes___ (*list what topic/feature you are focusing on*).
(*Think about whether you would use the topic page or the map tool.)

The topic page is an easier for students to use and to navigate. Most of the images found on this page will have access to a link where students can find the Image Identification number. The map tool is extremely useful, especially when a group of students have a specific area they are interested in observing. There is a Quick Start Guide that can help the students learn how to use 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 images at any time.

The image identification number for all visible images starts with a V. For students actually implementing their experiment design to answer a science question, we highly encourage they use visible images only and not the infrared images.

3. For each image I observe, I would also write down whether it had 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,

Extensions:

- Each student group could actually conduct their science experiment by implementing their experiment plan and testing their working hypotheses. (For this, you can use Student Worksheet V)
- Students could explore the global map of Mars and examine THEMIS images by focusing on regions of Mars. This map is available at <http://themis.asu.edu> (click on the *Map of All Images* link).
- If your student groups are large (at least 8 students), each student group could actually conduct their science experiment by implementing their experiment plan, testing their working hypotheses, and coming to a conclusion about the answer to their question. Groups of at least eight students could participate in the Archived format of the Mars Student Imaging Project (MSIP) and could publish their science question and results on the MSIP Team Results website (<http://msip.asu.edu>)
- If each of your student groups has a chance to discuss their science question, experiment design and working hypotheses, the class could vote on which question seems to be the most answerable using THEMIS images of Mars and the most interesting. Students could then focus, as a team, on their one question, and put together a team proposal to actually propose to use the THEMIS camera to take a brand new image of Mars for their research. Participation in the Mars Student Imaging Project (MSIP) gives students this opportunity. For more information, visit the MSIP Website (<http://msip.asu.edu>) or contact us at msip@asu.edu.





Question Mars Student Worksheet I

Name(s) _____

Date _____

Establishing a Research Topic

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

2. After the class discussion, list the six major categories of topics the class will 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: _____



Question Mars Student Worksheet II

Name(s) _____

Date _____

Making Observations of THEMIS Images

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). 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:

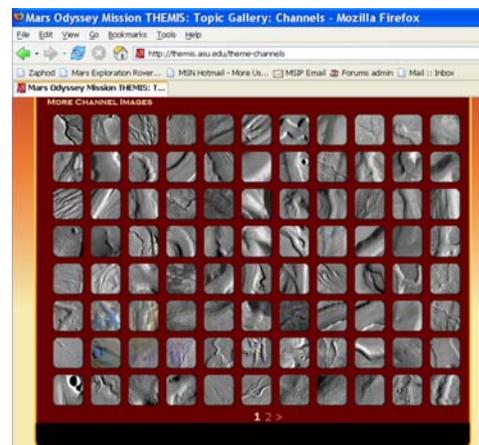


2. Click on the topic your group has been assigned: For Example:



3. Click on any of the thumbnails to see a THEMIS image of Mars related to your topic.

Each of the small squares is a thumbnail.

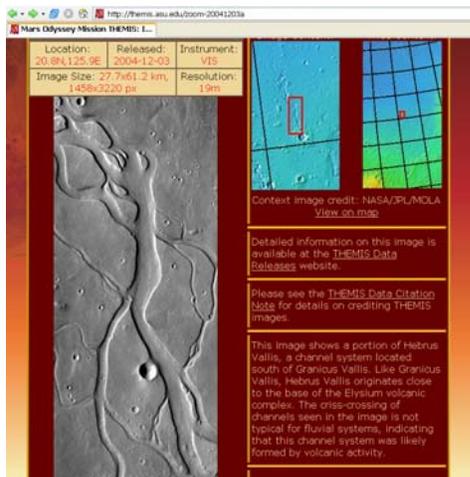




Question Mars Student Worksheet II

(cont'd)

Once you click on a thumbnail a new window will open showing you a THEMIS image. You can get an enlarged view of the image by clicking on the image.



4. Log the information on the observation table. Make observations of a minimum of 4 images. The information you will fill in is:
 - a. Name of Surface/Geologic Feature(s) Observed: Name the **specific** surface/geologic features you can see in each image. For some images you may be able to identify more than one surface/geologic feature. If you find the same surface/geologic feature in multiple images, be sure to include that same feature 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. Sketch the Feature(s): Make a sketch or drawing of the portion of the THEMIS image that shows the feature(s) you are observing.
 - c. Specific Observations of Feature(s): Write down specific observations of the feature(s) you see including any information you find especially interesting about the feature(s), or patterns you may want to look for with these features in other images.

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

Name of Surface/Geologic Feature(s) Observed	Sketch of Surface/Geologic Feature(s)	Specific Observations of Surface/Geologic Feature(s)
Channel with craters		<ul style="list-style-type: none"> -Channel does not seem very wide -Channel branches off in places -Small craters both on the outside and inside of channel



Question Mars Student Worksheet II

Making Observations of THEMIS Images

Name of Surface/Geologic Feature(s) Observed	Sketch of Surface/Geologic Feature(s)	Specific Observations of Surface/Geologic Feature(s)



Question Mars Student Worksheet II

Making Observations of THEMIS Images

Name of Surface/Geologic Feature(s) Observed	Sketch of Surface/Geologic Feature(s)	Specific Observations of Surface/Geologic Feature(s)



Question Mars Student Worksheet III

(Secondary Grade Level)

Name(s) _____

Date _____

Question Development – Refining Questions

1. 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 a THEMIS image. 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.

Look back at your original five questions from the Question Mars Student Worksheet I. For each of your questions, evaluate if images from the THEMIS camera are the correct tool to help you answer your original questions.

Question 1:	Yes	No	Not Sure
Question 2:	Yes	No	Not Sure
Question 3:	Yes	No	Not Sure
Question 4:	Yes	No	Not Sure
Question 5:	Yes	No	Not Sure

2. Now that you have a better idea as to what you can see in THEMIS images, create three new questions that focus on specific features you can see or observe. Two important points to think about when creating your refined questions are:

- a. Focus on Identified Surface/Geologic Features: Look at your THEMIS Observation sheet. Choose a feature you were able to identify in one or more THEMIS images as the focus of your question.
- b. Key Question Words: Here are some suggested key words/phrases you may consider using:
 - Is there a relationship between _____ and _____?
 - What is the size range of _____?
 - Where do _____ occur on or around _____?

Question 1: _____

Question 2: _____

Question 3: _____



Question Mars Student Worksheet III

(Elementary Grade Level)

Name(s) _____

Date _____

Question Development – Refining Questions

After making your observations of THEMIS images, you now may be curious and have questions about the features you have seen! Anything you are curious about can be formed into a valid question. For any science experiment, a question that is asked should be able to be answered using the tools you have available. Your tools are the THEMIS images.

As you begin, list the name of a specific surface/geologic feature you are curious about. Look back at your sketches and observations and create a new question that asks about the **shape(s), or size(s) or where this feature may form**. You may have other ideas of questions you can ask, but make sure you can answer them by looking at images of Mars.

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

Sample Question: Are dunes always found in the bottoms of craters?

Create your new questions below:

Name of Surface Feature: _____

Question 1: _____

Name of Surface Feature: _____

Question 2: _____

Name of Surface Feature: _____

Question 3: _____



Question Mars Student Worksheet IV

Name(s) _____

Date _____

Experiment Design and Hypothesis Development

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 or 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?



Question Mars Student Worksheet IV (cont'd)

5. Based on your current observations, list three possible outcomes to the answer to your question? (These will become your three working hypotheses.)

A.

B.

C.

6. In science, experiments need to be designed so they are repeatable. This allows others to conduct the experiment following the same step-by-step procedure to get the same 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 hypotheses. Would that 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?



Question Mars Student Worksheet V

Name(s) _____

Date _____

Experiment Design – Refining Your Experiment

1. When designing an experiment to answer a question, you need to be able to describe, in as much detail as possible, the step-by-step plan of how you would go about answering your question and/or testing your working hypotheses? 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 I could make observations of that pertain to my question and hypotheses. 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 images at any time.
3. For each image I observe, I would also write down whether it had 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 still would be 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 **latitude/longitude** 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.)

2. How will conducting each step of your test ensure that you have a complete and unbiased data set?