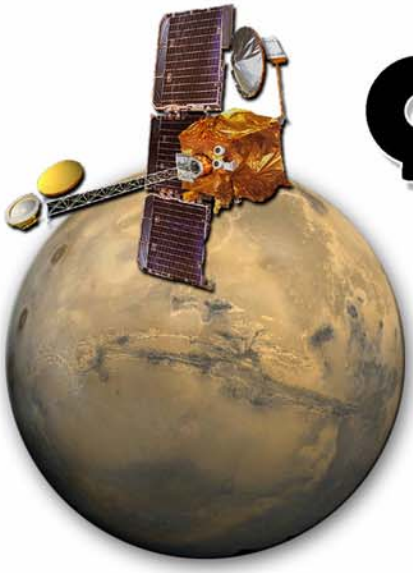
Arizona State University

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.

TEACHER GUIDE

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 Handbook: Worksheets 1, 2, 3, and 4* (For elementary groups only worksheets 1, 2, and 3.) Optional: For upper level students actually designing an experiment, you may consider using the *Question Mars Student Worksheet 5*
- 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 Identification Charts

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

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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 1, 2 and 3*.

Introduction:
Have students read the Student Background information sheet to get an introduction to the lesson. Discuss as necessary.

Part 1: Establishing a Research Topic and Brainstorming Questions (*Student Worksheet 1*)
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 1: 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 1*. **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 1*, 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 2*)

1. Using the *Question Mars Student Worksheet 2: 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.*

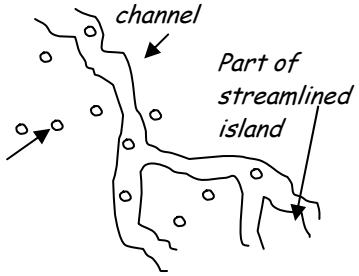
2. When filling out the *Student Worksheet 2*: *Making Observations of THEMIS Images*, students should use the **Feature ID Charts** provided to identify and name specific surface/geologic features they can see in each THEMIS image. For each THEMIS image they observe students should:

- 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.).
- Click on the THEMIS Data Releases link in order to write down the Image ID #. If this link is not available, students should write down the title of the image or indicate the page, column and row number as a way to possibly relocate that image at a later time.
- 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 students can fill out the 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*

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. The more images they observe, the better they can look for patterns. 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 3)*

1. Once students have filled out their *THEMIS Observation Tables*, have them think about refining their questions to focus on specific surface/geologic features they have observed in images. Reassure students that even if their new questions are completely different from their original questions, those original questions were still valid. This exercise asks students to focus on their primary tool to answer the questions, which are THEMIS images.

2. This section will ask students to follow three steps in order to help them refine their potential research questions:

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

STEP ONE

Here are some important hints for students to create their list of three refined questions:

- Identified Surface/Geologic Features: Have students look at their *THEMIS Observation Tables*. They should choose a **feature or combination of features** (sand dunes, lava flows, lava tubes, etc.) they were able to identify in one or more THEMIS image as the focus of their question. They must be able to answer the question by looking at images.
- 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 some examples of questions students may create using key words or phrases that are suggested:

Name of Surface Feature(s): *Lava tubes*
- What is the size range of _____ around Olympus Mons?
- (What is the size range of ***lava tubes*** around Olympus Mons?)

Name of Surface Feature(s): *Wind streaks OR Lava tubes*
- 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?)

Name of Surface Feature(s): *Craters and sand dunes*
- Is there a relationship between _____ and _____?
  (Is there a relationship between **crater size** and evidence of **sand dunes**?)

Name of Surface Feature(s): *Lava tubes and volcanoes*
- Where do _____ occur on or around _____?
  (Where do **lava tubes** occur on or around **volcanoes**?)

Remember: Students need to be able to answer their question by making observations of images. Questions like "Where does lava come from?" is not answerable by making observations of an image.

STEP TWO
Students need to evaluate their question to make sure it is a "doable question" – that is that they can answer it by primarily using THEMIS visible images. The suggested criteria listed are as follows:

- *Question can be answered by images taken by the THEMIS camera.* Student questions need to be answerable by looking at THEMIS images. They can certainly look at other data sets, but the THEMIS data should be their main tool.
- *Question includes the name(s) of the surface geologic feature(s) you want to study.* Students should actually include the name the geologic feature their research will focus on within their question.
- *Question focuses on one or more of the following aspects of geologic features: size(s), shape(s), where features form, or other.* Students will need to critically think about if their question addresses one of these aspects or something else that perhaps is not listed.
- *Question* ***does not*** *focus on* ***HOW*** *features form.* Students sometimes ask questions that focus on how features form. These questions are not answerable by looking at visible images of Mars.
- *Question includes one of the following words: evidence, size, shape, similarities, differences, relationships, patterns, or _____.* These are not the only words students could use in their question, but students should have a question word that allows them to gather visual data that will enable them to answer that question. Visual data can be observations of images and/or measurements of features within images as well.

Students should evaluate the three questions they developed in order to see which of their questions may be the best potential science question for the team to focus their research on.

STEP THREE
Once students have narrowed down their three questions to one potential question they feel is best, they should discuss and debate their question with other team members. As a team, students need to decide upon one final science question they can focus on. Encourage students not to feel overly "possessive" of their own created question. Their creation and participation in the team discussions and decisions will help them select the best and most interesting question for the team to focus on.

Once students select their final question, they should go through the checklist criteria once again.

Part IV: Experiment Design and Hypothesis Development (*Student Worksheet 4*)
(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 4: 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: *"Is there a relationship between crater size and sand dunes?"*

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

   Craters and sand dunes

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 that have craters in them – I will not focus on any one part of the planet

   OR

   I would look for images in the southern hemisphere of Mars.

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

   1 5 - 10 <u>20 - 40</u> 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 at least 20 images so that we could look images both with and without sand dunes to see if we notice any trends.

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

   We will need to estimate the size of the craters in our images. We can do that by knowing a THEMIS visible image is ~18km across and so we can estimate the diameter of any crater within an image.

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.

   Students should create a hypothesis based on observations they have made in the activity.

   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 5 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.*

   Note: Students can form their hypothesis based purely on their observations OR they can base it on their observations AND connect what they know about how a geologic process works to their 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 <u>*sand dunes and craters*</u> (name the geologic feature you are looking for)

- Images in regions of Mars such as _____*anywhere there are craters*_____
- __*40*___ # of images to answer the question and support or refute your hypothesis
- Measurements of _*approximate crater size*_____ (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?

Students should fill in the appropriate information in the blanks provided.

For the second part of the question they may write down an answer that states, "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 5*) - 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 5* 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 __*sand dunes*____ (*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, that still would be valuable data. The specific feature/s I would be looking for are: *sand dunes (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.

   Students should be sure to record this information so that they can possibly map their data points on a map at some point.

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 if necessary.)

The other information students collect should be based on their science question. They may want to include information such as:

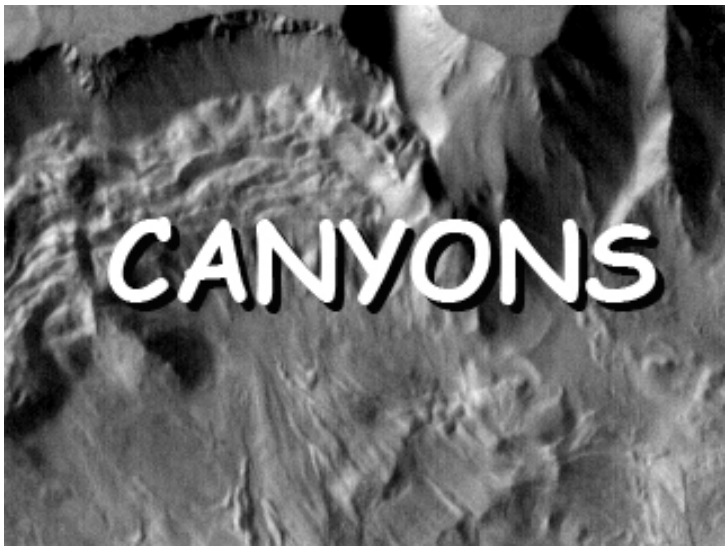
- *Elevation data (low elevation or high elevation – based on the MOLA map)*
- *Context Image Information: Describing the general terrain in the nearby area (the context) may help them be able to better understand what is going on in their image*
- *Measurements – if they are planning on making any*
- *Other Observations: Sometimes having a category such as this allows students to make any additional observations that may provide information they can use to help them come to a conclusion about their question and the answer.*
- *Other – there are many other pieces of data your students may consider gathering.*

Closure:
Ask student group volunteers to discuss the question their group identified as one that could be answered using THEMIS images. As they talk about their question, have them sketch on the board the main surface/geologic feature they are focusing their question on so the rest of the students can better understand. Students should explain at least one of their working hypotheses and discuss how they would go about testing that hypothesis.

Assessment:
Students should be assessed on their ability to create questions. Their first set of questions can be "big-picture" questions (although they may not be for every group) that may or may not be answered using THEMIS visible images. Students should be able to refine their "big-picture" questions to a more focused question that focuses on specific surface/geologic features that can be observed in images of Mars. You can assess your students during their closure discussions or by looking at their worksheets.

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 5*)
- 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.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