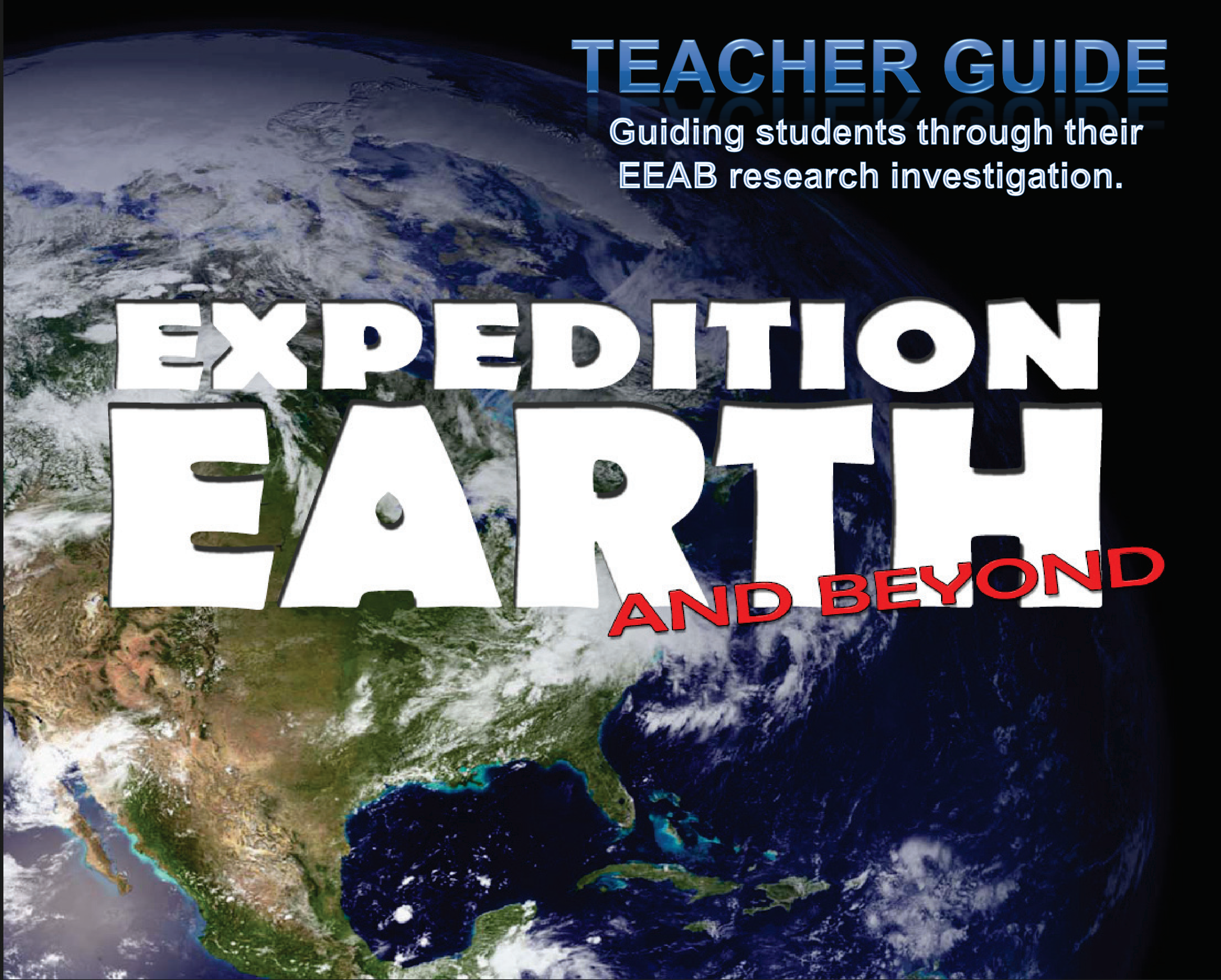


TEACHER GUIDE

Guiding students through their EEAB research investigation.

EXPEDITION EARTH AND BEYOND

STUDENT SCIENTIST GUIDEBOOK

EXPEDITION EARTH AND BEYOND

STUDENT SCIENTIST GUIDEBOOK

Teacher Guide

Written and Developed by:

Paige Valderrama Graff, *Science Education Specialist, Expedition Earth and Beyond Director*
Astromaterials Research and Exploration Science ARES Directorate
ARES Education Program, NASA Johnson Space Center
JACOBS – Engineering Science Contract Group (ESCG)

Edited and reviewed by the following individual within the Astromaterials Research and Exploration Science (ARES) Directorate at the NASA Johnson Space Center:

Marshalyn Baker, *Classroom Teacher*
Trevor Graff, *Planetary Scientist*
Charles Lindgren, *Classroom Teacher*
Michele Mailhot, *Classroom Teacher*
Tim McCollum, *Classroom Teacher*
William Stefanov, *Chief Scientist*
Susan Runco, *Physical Scientist*
Kim Willis, *Principal Geoscientist*

EXPEDITION EARTH AND BEYOND (EEAB) STUDENT SCIENTIST GUIDEBOOK
Teacher Guide

Goal: The goal of the *Expedition Earth and Beyond Student Scientist Guidebook* is to provide students with an inquiry-based approach to conducting a student-led research investigation in the classroom.

Objectives: Students will:
1. Be introduced to important aspects and steps involved in the process of science.
2. Initiate and complete a research investigation including:
   - Identifying a preliminary question
   - Making initial observations
   - Conducting background research
   - Creating an experimental design
   - Collecting and compiling data
   - Creating and making observations of data displays
   - Analyzing and interpreting data
   - Drawing conclusions
   - Sharing research

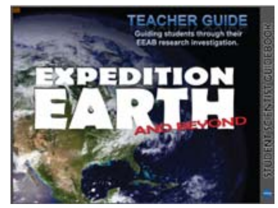
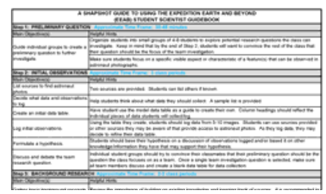
Grade Level: 5 – 12
This resource can be used across a wide range of grade levels. Depending on the grade level of your students, you might consider the following:

a) The complexity of student questions will vary based on grade level. Students in lower grade levels may likely ask more concrete questions. Older students should be encouraged to ask questions that involve higher level thinking.
b) The variety of sources used to answer a student investigation will vary based on grade level. Students in lower grade levels may ask questions that use only one or two sources of data. Older students should ask questions that require more than one source of data to answer their question.
c) Time dedicated to class discussions will vary based on grade level. For younger students, you may dedicate more time to class discussions. Older students should be able to work more independently on their research; however, you are still encouraged to have class discussions ensuring an understanding of each step within the process of science.
d) Data display options chosen may vary based on grade level. Students in higher grade levels may chose to include more complex data displays to analyze.
e) Analysis and interpretation of data will vary based on grade level. Younger students will likely have a more concrete analysis of their data, whereas older students should be able to demonstrate higher level thinking within their analysis.

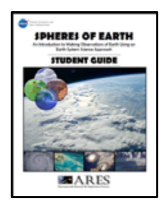
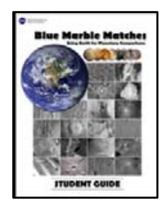
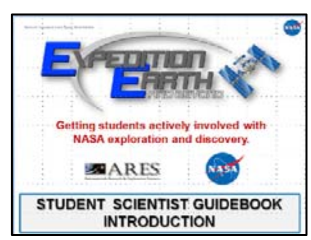
Depending on the grade level and abilities of your students, be flexible and sensitive to your students' needs as they work to understand each step of their investigation.

Time Requirement: ~15 class periods minimum

Materials:

Resource	*Notes About Resource*	*Thumbnail of Resource*
Expedition Earth and Beyond Student Scientist Guidebook	Recommended to provide one *Guidebook* per student or one per group of ~4 students. As your students use the *Guidebook* they will need periodic access to computers.	
Expedition Earth And Beyond Student Scientist Guidebook Teacher Guide	*Teacher Guide* provides information on the overall goal and objectives of the *Student Scientist Guidebook* as well as alignment to standards and helpful planning resources. Helpful planning resources integrated as part of this Teacher Guide include: • *Snapshot Guide to Using Expedition Earth and Beyond Student Scientist Guidebook:* This snapshot view will give you a 3-page view of the main objectives and helpful hints for each step of the process of science.	 

Additional Useful Resources:

Resource	*Notes About Resource*	*Thumbnail of Resource*
Launchpad Activities	These are inquiry-based optional activities to use with your students that give your students experience working with astronaut images. Examples of Launchpad activities include the *Spheres of Earth*, *Blue Marble Matches,* and *Oh What A Pane!* Launchpad activities are available at: http://ares.jsc.nasa.gov/ares/eeab/curricularmaterials.cfm	 
Expedition Earth And Beyond Student Scientist Guidebook Introduction	This presentation provides an introduction to important aspects of student-led research and an overview of the 9-step process of science students will use as they conduct their research investigation.	

Expanded Version of the Student Scientist Guidebook	This Expanded Version of the Student Scientist Guidebook includes expanded details and explanations of each step of the process of science. Consider using any or all parts of the Expanded version as you see fit.	
Student Scientist Guidebook Model Investigation	This complete and thorough research investigation can be used as an example to help guide students through each step of their research.	

Standards:
The following standards are addressed with the *Expedition Earth and Beyond Student Scientist Guidebook Introduction*, *Model Investigation*, and the *Student Scientist Guidebook* itself. The degree in which these standards are met depends on the research topic, question, experiment design, and data analysis techniques used.

National Science Standards:
- CONTENT STANDARD A: Science as Inquiry
- CONTENT STANDARD D: Earth and Space Science
- CONTENT STANDARD G: History and Nature of Science

Content Standard A: Abilities Necessary to Do Scientific Inquiry
- Identify questions that can be answered through scientific investigations.
- Design and conduct a scientific investigation.
- Use appropriate tools and techniques to gather data and extend the senses.
- Develop descriptions, explanations, predictions, and models using evidence.
- Think critically and logically to make the relationships between evidence and explanations.
- Recognize and analyze alternative explanations and predictions.
- Communicate scientific procedures and explanations.
- Use mathematics in all aspects of scientific inquiry.

Content Standard D: Structure of the Earth System
- Landforms are the result of constructive and destructive forces such as crustal deformation, volcanic eruption, deposition of sediment, weathering, and erosion.
- Global patterns of atmospheric movement influence local weather.

Content Standard D: Earth's History
- The planet's history is influenced by occasional catastrophes such as the impact of an asteroid or comet.

Content Standard D: Earth in the Solar System

- The Earth is the third planet from the Sun in a system that includes the Moon, the Sun, eight other planets and their moons, and smaller objects, such as asteroids and comets.

Content Standard G: Nature of Science

- Science distinguishes itself from other ways of knowing and from other bodies of knowledge through the use of empirical standards, logical arguments, and skepticism, as scientists strive for the best possible explanations about the natural world.
- Scientific explanations must be consistent with experimental and observational evidence about nature, and must make accurate predictions about systems being studied. They should also be logical, respect the rules of evidence, be open to criticism, report methods and procedures, and make knowledge public.
- All scientific knowledge is subject to change as new evidence becomes available.

Content Standard G: Science as a Human Endeavor

- Women and men of various social and ethnic backgrounds engage in the activities of science.
- The work of science relies on basic human qualities, as well as on scientific habits of mind.
- Scientists do and have changed their ideas about nature when they encounter new experimental evidence that does not match their existing explanations.

NCTM Principles and Standards: Content Standards

- Number and Operations
- Patterns, Functions, and Algebra
- Geometry and Spatial Sense
- Measurement
- Data Analysis, Statistics, and Probability

NCTM Principles and Standards: Process Standards

- Problem Solving
- Reasoning and Proof
- Communication
- Connections
- Representation

Common Core State Standards: Mathematical Practices

- Make sense of problems and persevere in solving them.
- Reason abstractly and quantitatively.
- Construct viable arguments and critiques the reasoning of others.
- Model with mathematics.
- Use appropriate tools strategically.

- Attend to precision.
- Look for and make use of structure.
- Look for and express regularity in repeated reasoning.

Common Core State Standards: Content Standards
- Ratios and Proportional Relationships
- The Number System
- Expressions and Equations
- Functions
- Geometry
- Statistics and Probability

Geography Standards:
- The World In Spatial Terms
- Places and Regions
- Physical Systems

Technology Standards:
- Basic Operations and Concept
- Social, Ethical, and Human Issues
- Technology Productivity Tools
- Technology Communication Tools
- Technology Research Tools

Useful Websites:
- Expedition Earth and Beyond: http://ares.jsc.nasa.gov/ares/eeab/index.cfm
- Expedition Earth and Beyond Student Wiki: http://eeabstudents.wikispaces.com
- Expedition Earth and Beyond Teacher Wiki: http://eeabteachers.wikispaces.com
- Gateway to Astronaut Photography of Earth: http://eol.jsc.nasa.gov
- Additional links to Useful Websites are resources available at: http://ares.jsc.nasa.gov/ares/eeab/resources.cfm
- NASA Earth Observatory: http://earthobservatory.nasa.gov
- MY NASA DATA: http://mynasadata.larc.nasa.gov/
- Open NASA Data: http://data.nasa.gov/

Printing Alternative: As your resources permit, you can download the PDF of the *Expedition Earth and Beyond Student Scientist Guidebook* on your student computers and have students fill in answers to questions, save their work, and continue each day without printing anything. You will need to have a program that will enable this. One recommendation is FoxIt. FoxIt allows you to open PDFs, type in answers, and save your work. It is a free download available at: http://www.foxitsoftware.com/pdf/reader/. You may want to check to make sure documents save correctly before students finish their work. Adobe reader may save typed in work. Other alternatives may be available. We encourage you to test whatever means you choose to use to ensure it works.

Introduction and Background

The Expedition Earth and Beyond program is designed to promote authentic research investigations in the classroom using NASA data and resources. The program utilizes astronaut photographs as a hook to get students interested in conducting a research investigation. Students and teachers have a range of activities in which to participate, all of which are designed to promote STEM-literacy in the classroom.

Students can participate in any or all of the following opportunities:

1. Complete one or more stand-alone, hands-on activities (referred to as a *Launchpad Activities)*. *Launchpad activities* are designed to expose students to astronaut photographs in order to help them gain an interest in a feature to focus on for a student investigation project. *Launchpad activities* are available at: http://ares.jsc.nasa.gov/ares/eeab/curricularmaterials.cfm
2. Conduct a student-led research investigation about Earth (or planetary body comparison) using astronaut photos as one source of data. **The *Expedition Earth and Beyond Student Scientist Guidebook* is the main resource used to help guide students through such an investigation.**
3. Get input from a mentor as they progress through their research. Student teams working as one class can get partnered with a mentor who will provide comments, input, and suggestions on student research as they step through the process. Mentor communication takes place through the use of a *Team Workspace Wiki* (See details below on the Expedition Earth and Beyond Wikispaces).
4. Submit a *Data Request Form* to have a new image of Earth acquired by an astronaut onboard the International Space Station (ISS). Classes working as one team can submit a data request however, if there are multiple small groups conducting research in one class, only one request per class can be submitted.
5. Share/present student team research to scientists and potentially other participating student teams across the nation. Students can do this by either posting their research on the *Team Workspace Wiki* and/or presenting their research "live" to scientists.
6. Participate in distance learning *Classroom Connection Webinar*s to build background knowledge and connect with NASA and university scientists. Information about *Classroom Connection Webinars* are posted at: http://ares.jsc.nasa.gov/ares/eeab/DLE.cfm

Expedition Earth and Beyond Wikispaces

Wikispaces is a proven leader in providing free wiki services to thousands of schools across the country and around the world. The Expedition Earth and Beyond program has three Wikispaces areas, each designed for a specific purpose.

- *EEAB Student Wiki:* http://eeabstudents.wikispaces.com
  This wiki is designed to provide helpful information for students conducting research through the Expedition Earth and Beyond Program. This page can be accessed by anyone.

- *EEAB Team Workspace Wiki:* http://eeabstudents.wikispaces.com → *Team Workspace Links (listed on the menu bar on the right side of the page).* This wiki, available from the *EEAB Student Wiki* site, is designed to provide an optional Team Workspace for each participating team. This *Team Workspace Wiki* area provides a place where students can post the progress of *their* research as they step through the 9-step process of science modeled in the *EEAB Student Scientist Guidebook*. Classes participating as one team will have the opportunity to work with a mentor through the discussion area of their *Team Workspace Wiki*. Most *Team Workspace Wikis* can be viewed by anyone, but can *only be edited* by the teacher and any students with logins and passwords. Teachers can request logins and passwords for students. Participation in the discussion section of the wiki is also limited to those with a login and password. This includes the teacher, mentor, and any students with login privileges. A private *Team Workspace Wiki* is available upon request. A private wiki would be viewable only by those with login privileges.

- *EEAB Teacher Wiki*: http://eeabteachers.wikispaces.com
This wiki is designed to provide a place for teachers participating in Expedition Earth and Beyond to ask questions, post comments, suggestions, ideas and/or communicate with other teachers. This wiki also has other resources you might find helpful as you participate in the program. This page can only be accessed by teachers who are members of this wiki. To join this wiki go to http://eeabteachers.wikispaces.com, create a username and password, and click join. Once your request is received, you will be granted access to this wiki.

STUDENT SCIENTIST GUIDEBOOK TEACHER GUIDE AND PROCEDURES

This *Teacher Guide* is designed to provide you with information to help you best utilize the Expedition Earth and Beyond resources to help facilitate student-led research in your classroom and allow you to see the alignment to Content Standards. Additionally, this guide provides suggested procedures to use with your students as they conduct their research investigation. You are encouraged to revise procedures as you see fit for your level of students.

To help you plan for your implementation of the Expedition Earth and Beyond student research in the classroom, we recommend you do the following:

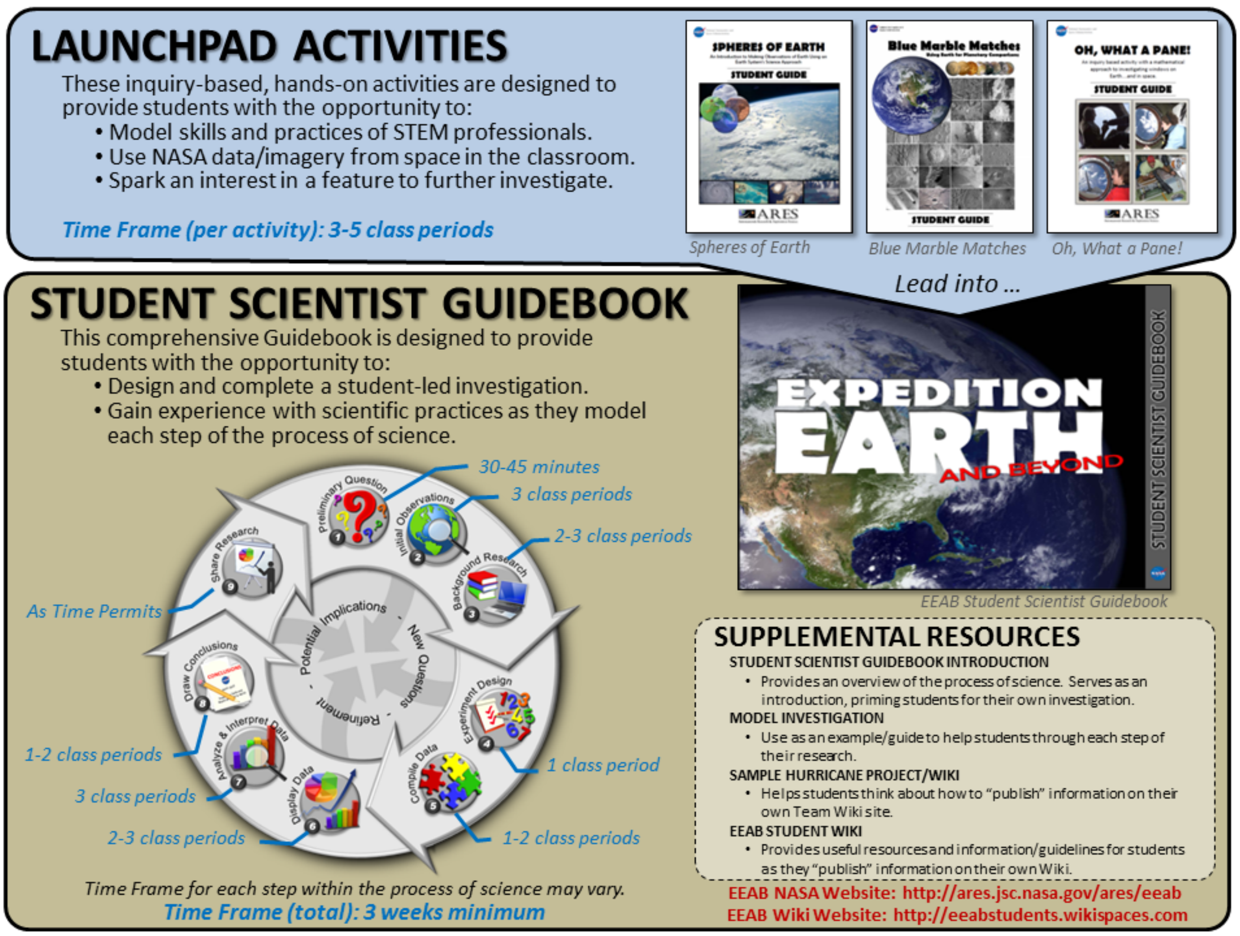
1. Complete at least 1 of the Launchpad activities with your students. Any of these activities (*Spheres of Earth, Blue Marble Matches, or Oh, What A Pane!*) can be implemented in the classroom over a 3-5 day time frame. These inquiry based activities will help students gain experience using NASA data/imagery from space and help spark an interest in a feature to further investigate.

    - Spheres of Earth Activity: Introduces students to Earth's systems and gives them experience looking at images of Earth taken from space.

- Blue Marble Matches Activity: Introduces students to geologic processes and features on Earth and on other planetary bodies.
- Oh, What A Pane!: Introduces students to a mathematical approach to investigating windows on Earth and in space!

2. Use the Expedition Earth and Beyond Student Scientist Guidebook to help guide your students as they experience each step of the investigation process. You would need a minimum of 3 weeks, however, if you have a longer time frame (6-9 weeks) available that would enable students to more deeply internalize these scientific practices used by STEM professionals.

This graphic helps illustrate these above points:



There are 9-steps in the process of science, as modeled in the *Expedition Earth and Beyond Student Scientist Guidebook*. Those steps and suggested time frames to implement each step are as follows (time frames may vary):

- Step 1: Preliminary Question **(30-45 minutes)**
- Step 2: Initial Observations **(3 class periods)**
- Step 3: Background Research **(2-3 class periods)**
- Step 4: Experiment Design **(1 class period)**
- Step 5: Collect and Compile Data **(1-2 class periods)**

- Step 6: Display Data **(2-3 class periods)**
- Step 7: Analyze and Interpret Data **(3 class periods)**
- Step 8: Draw Conclusions **(1-2 class periods)**
- Step 9: Share Research **(As Time Permits)**

Time frames can vary depending on the needs of your students.

You are encouraged to have your students complete an investigation focusing initially on an aspect of Earth, however, students can also use the *Student Scientist Guidebook* to conduct a planetary comparison investigation. Students conducting a planetary comparison investigation should be sure to conduct background research to gain an understanding of the feature and related process on Earth. This will allow them to apply that knowledge as they conduct their planetary investigation.

TIPS AND TIME FRAMES FOR USING THE STUDENT SCIENTIST GUIDEBOOK

The following information is designed to provide you with the main objective(s) of each step within the process of science as well as give you helpful hints/suggestions as you guide your students through their investigation:

STEP 1: PRELIMINARY QUESTION (30-45 minutes)

Main Objective(s):	Helpful Hints/Suggestions:
Guide individual groups to create a preliminary question to further investigate.	Organize students into small groups of 4-8 students to explore potential research questions the class can investigate. Keep in mind that by the end of Step 2, students will want to convince the rest of the class that their question should be the focus of the team investigation. Make sure students focus on a specific visible aspect or characteristic of a feature(s) that can be observed in astronaut photographs.

STEP 2: INITIAL OBSERVATIONS (3 class periods)

This step covers a number of objectives. By providing students in small groups with the opportunity to experience the objectives listed, this will help them better understand how to achieve these tasks as they continue with their research.

Main Objective(s):	Helpful Hints/Suggestions:
List sources to find astronaut photos.	Two sources are provided. Students can list others if known.
Decide what data and observations to log.	Help students think about what data they should collect. A sample list is provided.
Create an initial data table.	Have student use the model data table as a guide to create their own. Column headings should reflect the individual pieces of data students will collect/log.

Log initial observations.	Using the table they create, students should log data from 5-10 images. Students can use sources provided or other sources they may be aware of that provide access to astronaut photos. As they log data, they may decide to refine their data table.
Formulate a hypothesis.	Students should base their hypothesis on a discussion of observations logged and/or based it on other knowledge/information they have that may support their hypothesis.
Discuss and debate the team research question.	Individual student groups should try to convince their classmates that their preliminary question should be the question the class focuses on as a team. Once a single team investigation question is selected, make sure all team members discuss and create a blank data table for data collection.

STEP 3: BACKGROUND RESEARCH (2-3 class periods)

<table>
<tr><th>Main Objective(s):</th><th>Helpful Hints/Suggestions:</th></tr>
<tr><td>Gather basic background research and information.</td><td rowspan="2">Review the importance of building on existing knowledge and keeping track of sources. It is recommended to divide students into 6-7 groups to log information from the 6-7 topics listed. You may choose to only focus on topics 1-6 as topic 7 deals with planetary comparisons. You may want to have students complete an investigation focusing on Earth first before they delve into a planetary comparison.

As students collect and log information, they should keep track of all sources used.</td></tr>
<tr><td>Log bibliographical and summary information from each source.</td></tr>
<tr><td>Continue to collect and log data.</td><td>Once students finish logging information on their assigned topic, they should collect and log data.</td></tr>
<tr><td colspan="2">By the end of this step, students should report out their information to the rest of the class. This will ensure all team members learn consistent and complete information regarding their investigation.</td></tr>
</table>

STEP 4: EXPERIMENT DESIGN (1 class period)

Main Objective(s):	Helpful Hints/Suggestions:
Finalize the team research question	Have students discuss the current research question and decide if the question can be refined.
Reformulate and finalize hypothesis	Once students have decided on a refined and final research question, they should reformulate and finalize their hypothesis. This refined hypothesis should be aligned with the final research question. Students should include observations and other knowledge that support this hypothesis.
STUDENTS SHOULD NOT MAKE MAJOR CHANGES TO THEIR QUESTION OR HYPOTHESIS FROM THIS POINT ON. ADDITIONAL DATA COLLECTED AND ANALYZED WILL ALLOW STUDENTS TO INDICATE IF THEIR HYPOTHESIS WAS SUPPORTED OR REFUTED.	
Finalize the plan on what data to collect and where students will gather that data.	Discuss each of the seven items listed as part of the experiment design. All students should be in agreement and have an understanding as to how they will address each of the methods listed.
Make sure everyone logs data consistently.	Have student use the model data table as a guide to create their own. Column headings should reflect the individual pieces of data students will collect/log.

STEP 5: COLLECT AND COMPILE DATA (1-2 class periods)

Main Objective(s):	Helpful Hints/Suggestions:
Compile all collected data into a Master Data Table(s)	It will be important to compile data collected from different team members into one Master Data Table. If students had multiple data tables (were collecting multiple types of data) they may have more than one Master Data Table. If student have hand-written data tables, it will be useful to transfer all the information into a spreadsheet. Make sure every data table includes a complete set of logged data.
Fill out and submit Data Request Form (optional)	If students would like to have new data acquired by an astronaut on the International Space Station, they can fill out a Data Request Form. Only one request permitted per class.

STEP 6: DISPLAY DATA (2-3 class periods)

Main Objective(s):	Helpful Hints/Suggestions:
Decide on the different ways to display collected data.	Discuss the four different types of data displays discussed in the guidebook. Have students brainstorm the types of data displays they think should be created.
Create data displays.	Once students have decided on the types of data displayed to be created, have different groups of students be responsible to create those displays. Displays should be available for all students to view and make observations.
List observations of data displays	Students should make observations of each data display. Use the Observation Table provided to help students organize their observations.
Discuss observations of each data display as a class. Encourage students to circle or highlight observations that seem especially relevant to the research question and hypothesis.	

STEP 7: ANALYZE AND INTERPRET DATA (3 class periods)

Main Objective(s):	Helpful Hints/Suggestions:
Examine observations from each data display.	Have students focus on the observations they highlighted or circled as being especially important. These observations will be included in the first column of the Analysis and Interpretation of Data table.
Make interpretations of those observations (how observations relate to and help students answer their question).	Students should discuss how each individual observations listed can be interpreted to help them make a connection or inference related to their question and/or hypothesis. Students should write their interpretation of each observation in the 2nd column of the data.
Provide specific evidence from the data displays or background knowledge that support each interpretation.	Students should list additional evidence that supports the interpretation of their observation. This can be evidence from other data displays or from background knowledge they gained during their research.
Make additional copies of the Analysis and Interpretation of Data table as necessary.	
Consider potential erros, inaccuracies, misinterpretations or limitations of data.	Students should reflect on their research and list potential errors, inaccuracies, misinterpretations or limitations of data. Stating these challenges or aspects of their research will help them as they consider and draw conclusions about their research question and consider whether their hypothesis was supported or refuted.

STEP 8: DRAW CONCLUSIONS (1-2 class periods)

Main Objective(s):	Helpful Hints/Suggestions:
Restate the research question and answer it.	As students state and answer their question, they should summarize pertinent evidence that supports their answer.
Restate the hypothesis and indicate whether it was supported or refuted.	As students state whether their hypothesis was supported or refuted, they should summarize pertinent evident that supports their answer.
Emphasize to students that it is not good enough to simply answer their question or state whether their hypothesis was supported or refuted. Students MUST be able to summarize specific and supporting evidence that support their answers.	
Consider what new research could be conducted based on the investigation.	Discuss with students how knowledge gained generally sparks new questions. Science is about continuing to explore and gain new knowledge. Curiosity never ends, and never does science.
Acknowledge those that helped you with your investigation.	Let students know that professional scientists always acknowledge those that have helped them with their investigation. This is considered a professional courtesy.
Reflect on your investigation and think about how it could have been improved.	Students should discuss how the investigation could be improved if it were to be done again. This will help students attack new problems and investigations even better in the future.

STEP 9: SHARE RESEARCH (As Time Permits)

Main Objective(s):	Helpful Hints/Suggestions:
Share research with others.	Science really is not considered complete until it is shared with others. Options for sharing students' research could be a school presentation, publishing their research on their own Expedition Earth and Beyond Team Wiki, writing a research paper, or presenting their research to professional scientists.
Discuss with students the numerous skills they have experienced and improved throughout their investigation. This includes the knowledge they have gained, their communication skills, their discussion and debate skills, and their understanding of skills and practices used by actual STEM professionals.	

As your students complete their research investigation, have them consider whether the feature(s) they studies exist on other planetary worlds. Students may want to consider conducting similar research focusing on another planetary body.