# Science and Mathematics Module

NASA

Data Analysis and Generalizations

This module focuses on the solar wind information obtained by the Genesis spacecraft. The Genesis spacecraft collects pristine solar wind material (ionic particles from the Sun) that will provide clues about the elemental composition of the original solar nebula. For more information about the Genesis mission, go to: http://genesismission.jpl.nasa.gov/mission/index.html

The primary mission of Genesis is solar wind sample return. However, the spacecraft contains electron and ion monitors that send back information about the solar wind in near real time. *Data: Analysis and Generalizations* is an advanced high school module or post-secondary module that engages students in studying real solar wind information collected from the Genesis spacecraft and posted on the Los Alamos National Laboratory (LANL) Genesis Science Data Web site.
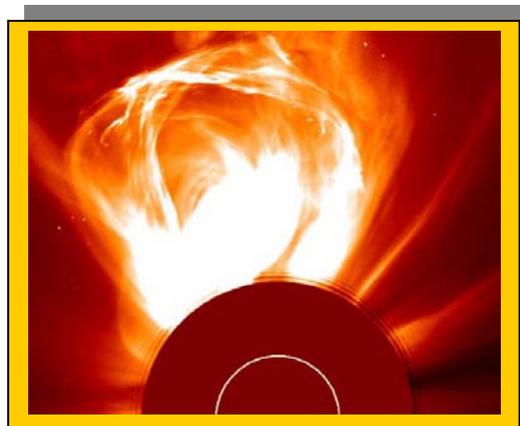
Data Analysis and Generalizations emphasizes experimental design and inquiry science concepts. The *National Science Education Standards* "Science as Inquiry" standard calls for students to learn how to analyze evidence and data. "The evidence they analyze may be from their investigations, other students' investigations, or databases. Data manipulation and analysis strategies need to be modeled by teachers of science and practiced by students. Determining the range of the data, the mean and mode values of the data, plotting the data, developing mathematical functions from the data, and looking for anomalous data are all examples of analyses students can perform." (NRC, 1996[1]). The *Principles and Standards for School Mathematics* data analysis and probability standards state that high school students should learn sophisticated ways to collect and analyze data and draw conclusions from data in order to answer questions or make informed decisions. The standards in the "Curriculum Connections" below will assist you in identifying the major concepts addressed in this module.

In *Data Analysis and Generalizations*, students ask questions that can be answered by analyzing this archived information. Though designed to be an open-inquiry investigation, teachers are provided some suggestions for guiding students who want or need assistance in designing and conducting the investigation. Students draw conclusions and make generalizations that are then reviewed by their peers. Finally, students communicate their investigations to an audience of their peers who will assist the instructor in assessing the process. This module is organized using a learning cycle and designed to be taught in a sequence. However, you are welcome to select among the activities that most closely align with your curriculum needs. If you are using Genesis science modules for the first time, read the User's Guide thoroughly before you begin. (View User's Guide as a PDF.)

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[1] National Research Council. 1996. Washington DC: National Academy Press

Module Planning Guide

Catch a Piece of the Sun
- Teacher Guide

Solar Wind Catcher
- Student Text

Summarizing
- Student Activity

Solar Wind
- Student Text

Briefing

Students are briefed on the Genesis mission and the three basic types of solar wind that are being detected by the Genesis Ion Monitor (GIM) and Genesis Electron Monitor (GEM). Students will develop an understanding of the Sun's solar wind, the Earth's magnetosphere, and how the Genesis spacecraft collected solar wind at L1.

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Exploring Data
- Teacher Guide
- Student Text

A First Look
- Student Activity

Exploration

In the activities of this module, the teacher's primary role is Socratic. Through effective questioning, students should become aware of the patterns found in the solar wind data.

In this activity, students will take a "first look" at actual solar wind data that has been collected and sent to Earth by the Genesis spacecraft. The data summary sheets contain seven panels: Speed, Temperature, Expected Temperature/Measured Temperature, Density, Helium ratio, Coronal Mass Ejection (CME), and Bi-Directional Electron Indicator (BDE).

Curriculum Connections
National Standards Addressed

National Science Education Standards

Grades 9-12
History and Nature of Science
- Science as a human endeavor
- Nature of scientific knowledge

Principles and Standards for School Mathematics

Grades 9-12
Data Analysis and Probability
- Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them.
- Select and use appropriate statistical methods to analyze data.
- Develop and evaluate inferences and predictions that are based on data.
- Understand and apply basic concepts of probability.

Developing an Investigation
- Teacher Guide

Exploring Data
- Student Text

A Closer Look at Solar Wind Regime Speeds
- Model Student Activity

A Closer Look
- Student Activity

Development

After the teacher models the development of an investigation from the solar wind information, students develop an investigation idea based on one of the questions they had in the Exploration section. Students will then organize and communicate the data in a meaningful way. Students will analyze the information in order to answer their questions and make models, generalizations or explanations. During this section, students are encouraged to use technology and mathematics to make sense of the information that is being analyzed in light of their question(s). Students will use statistical analysis and graphing technology to understand and organize the data and to communicate their explanations to peers. If several models, explanations, or generalizations occur due to this analysis, students will need to make decisions about which explanation best fits the evidence found in the data.

Revising an Investigation
- Teacher Guide

Peer Review
- Student Activity
- Student Text

Poster Rubric
- Student Activity

Interaction/Synthesis

Students refine their investigations by having their methodology, procedures, and data analysis reviewed in a peer review process. Through this process, students will have the opportunity to see the work of others in light of what they have already done. This gives students a chance to evaluate draft reports from peers using a rubric. One part of the peer review process gives the students a chance to discuss the evaluations with the reviewers. In this way, suggestions and

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arguments can be made clear for each study. Students then have the opportunity to make revisions or alter their explanations and generalizations based on peer feedback.

Using a rubric, students prepare to present their findings to the class as a poster session at a "State of the Solar System Conference." Each student will develop a one-page abstract that summarizes the process and findings. The poster will illustrate the question, methodology, and data (including anomalies) in the form of charts, illustrations, and graphs in order to show relationships. During the poster session, the students will communicate the process used, report any revisions made as a result of the peer review, and the generalizations resulting from their findings. During the poster session, the class will make recommendations and collaborate with the instructor to assess the student work using the same rubric that was used during preparation.

A Different Perspective

- Teacher Guide

A Look from a Different Perspective

- Student Activity

Assessment

Analysis of the additional data being collected by the Genesis Electron Monitor, processed on board the Genesis spacecraft, and found on the Los Alamos National Laboratory (LANL) Genesis data Web site, provides an authentic assessment activity that incorporates all of these requirements into this Data Analysis Module.

This activity concludes with six questions that should help you assess your students' ability to interpret the presented data, to deal with data that can be interpreted in more than one way, and to develop new questions that could be the basis of further scientific investigation.

Curriculum Connections
National Standards Addressed

Assessment Standard B
- Achievement and Opportunity to Learn Science must be Assessed

Assessment Standard C
- Assessment Tasks Are Authentic

This education module, *Data Analysis and Generalizations*, was developed by educators at Mid-continent Research for Education and Learning.

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