Dynamic Design: A Collection Process

Modeling Solar Wind Collection

TEACHER GUIDE

BACKGROUND INFORMATION

In this activity students will model how different materials collect different solar wind particles. In the Genesis spacecraft, the wafers will be made out of different materials in order to anlayze different elements and isotopes. All elements from atomic number 3 through 92 will be collected on all wafers, but some materials lend themselves for better analytical techniques for some elements than others. In the first activity, students will throw projectiles onto different surfaces and determine which projectiles embed into different materials. In the second activity, students will use UV sensitive beads to model the different materials and solar wind particles. Black light will be used to analyze the results. Finally, in part three, students will discover that there are no visible solar wind particles that will be collected on the wafers.

NATIONAL SCIENCE STANDARDS ADDRESSED

Grades 5–8
Science As Inquiry
Abilities Necessary to do scientific inquiry
Understandings about scientific inquiry
Science and Technology
Abilities of technical design

Grades 9–12
Science As Inquiry
Abilities Necessary to do scientific inquiry
Design and conduct scientific investigations
Formulate and revise scientific explanations and models using logic and evidence
Science and Technology
Abilities of technical design

(View a full text of the National Science Education Standards.)

NATIONAL MATH STANDARDS ADDRESSED

Grades 5–8
Math Standard: Statistics
Systematically collect, organize and describe data

(View a full text of the National Math Education Standards.)

MATERIALS

For each group of three to four students:
Part 1
Choose four projectiles. Examples include:

M & M's®	stone	cotton
plastic bead	rubber bead	hard candy
polystyrene	paper ball (wet and dry)	rice

Note: Each projectile should be similar in size.

Each of the four stations should include one of the following surfaces or surface materials:

bread spread with jelly	ping pong balls	M & M's®
moist sponge	cake with icing	stones
Jell-O® with whipped cream	polystyrene	prepared pudding
flour or dried rice	hard candies	plastic beads

Part 2

- Student Text "Continuous Collection"
- Small background frame master
- UV sensitive beads
- 3-4 forceps
- Glue stick and or two-sided tape
- Black light

Part 3

- One bowl of uncooked rice
- 10 small safety pins
- Blind fold
- Watch or clock (minute timer)

PROCEDURE (Part 1) Sticky Situation

1. Explain to students that the solar collectors on the Genesis spacecraft are wafers attached to a frame. The wafers are made of different materials based on the type of solar wind particles that the scientists plan to analyze. In this Exploration activity, students will throw objects and discover which projectiles embed into various surfaces.

2. Relate experiences where students have "played" with food. Have students share some experiences. On the board, list and describe the materials that will be used. Allow the students to predict which projectiles will embed into each surface and which will not. Solar wind particles will be embedded into the collectors so students should note only those projectiles that are embedded, and not just stuck on the surface. This would be a good opportunity for students to operationally define "embed." Students may use the following grid to help them make their predictions. Students may use this key:

E = projectile will embed **N = projectile will not embed** **?= unsure**

	Projectile 1	Projectile 2	Projectile 3	Projectile 4
Surface 1				
Surface 2				
Surface 3				
Surface 4				

3. Discuss with students what variables they should try to control. Some may include: size of the projectile, force with which it is thrown, and the distance from the launch site and the surface. List these and other variables on the chalkboard.

4. Distribute materials and let the students construct their projectiles. Once done, students should test their projectiles against the various backgrounds. One way to manage this is that there be a different surface at each workstation. Students could take their projectiles to the different workstations to complete their trials.

5. Students may record their results in the following table or they may create a table to record their data. Students should complete three trials per projectile per surface.

E = projectile embedded **S = projectile stuck** **N = projectile did not stick or embed**

Surface 1	Projectile 1	Projectile 2	Projectile 3	Projectile 4
Trial 1				
Trial 2				
Trial 3				

Drawing and Additional Observations:

6. Once students have completed their experiment, debrief students by asking these questions:
   a. Which surface had the most projectiles that were embedded? Expect more projectiles to be embedded into softer materials such as jelly, whipped cream, or icing. Materials that have spaces between particles such as dried rice, hard candies, stones, or plastic beads may also have projectiles embedded in them.
   b. Why do you think this is so? Students may suggest that softer materials provide less resistance to the projectiles.
   c. What may have caused your results to differ from those of another lab group? Perhaps variables such as projectile speed were different in other groups.
   d. What would you suggest next time to have more particles embed? (Answers will vary.) Use more force when throwing projectiles or using different materials.
   e. If you were going to design wafers to collect the most number of different kinds of projectiles, which surface would you choose and why? Answers will vary, but should be based on experimental results.
   f. If you were going to design boxes to collect specific projectiles, which would you choose? Answers should be based on experimental results. This should summarize the activity.

7. Assign the Student Text "Continuous Collection" to be read as homework or classwork.

PROCEDURE (Part 2) Better Beads

1. Students will read the Student Text "Continuous Collection". This text contains information about methods of collecting data, examples of collecting insects, and an analogy of sound relating to solar wind.

2. List the different materials (colors) of wafer material on the board. Ask each group to determine which type of bead they would like to use in their collector. Students should also note that there are some contaminants among the atoms they chose.

3. The beads change to a color when exposed to UV light (black light). To organize the materials, have each color of beads (when exposed) in a separate container. For instance, all white to red beads could be in a container marked silicon, all white to blue beads should be in a container marked sapphire, and so on. See bead colors and materials chart. Have another container with several colored beads and contaminants in another container marked “solar wind particles.”

4. Ask students to gather enough beads of one material to cover the hexagon on their student sheets.

5. Students should have several beads of one type. With their small

Bead Colors and Materials

You may use the following key for bead colors and materials.

Bead Color	Material
White to Red	Silicon
White to Blue	Sapphire
White to Orange	Aluminum
White to Yellow	Gold
White to Purple	Germanium
Silver to Copper	Contaminants

wafer and two-sided tape, students should apply the tape to the wafer and place the beads on the tape. The beads will represent the atoms that make up the elements of the wafer material.

6. Once the students have applied the beads to the wafers, ask them to place the wafers close to one another on a table. Students should get several beads from the container of "solar wind beads" (*an assortment of the various colors*). All students should throw the solar wind assortment beads at the wafers at the same time.

7. Each group should retrieve their wafer and take it to the ultraviolet light. Ask the class to then use an ultraviolet light to analyze the type of solar wind particles that were collected by noting the colors that are seen under the ultraviolet light. Students should record their results. For example, if the material used for the wafer turned blue during the UV analysis, any blue solar wind particles there were embedded in the wafer could not be analyzed. Certain materials were better for analysis of some elements than others.

8. Ask: "Were there any surprises? Did some materials collect solar wind better than others? Why do you think this is so?" (As in the Genesis mission, all solar wind elements will embed into the wafers and some materials were better for analyzing certain elements than others. In the actual mission the analysis will not be based on colors.)

9. Ask: "In what ways is this model similar to the actual Genesis mission? In what ways is the model different than the actual Genesis mission?" (When completing the analysis, the solar wind beads that were the same as the material in the wafer were impossible to detect.)

10. Ask: "What were some of the problems you encountered when trying to detect the beads that were embedded into the wafer?"

11. Ask: "How would you solve some of these problems?" (Use various materials for analyzing various solar wind particles.)

PROCEDURE (Part 3) Invisible Analysis

1. Explain to students that in the "Better Beads" activity, the model was insufficient because the collector wafers will not change color at all and that a non-visual analysis will have to take place.

2. Distribute materials for part 3. Explain that students will take turns trying to pick out the safety pins from the bowl of rice while blindfolded.

3. Have one student put the blindfold on and another student keep time. The blindfolded student will have one minute to pick out as many safety pins as possible. Once this is done, record results in a data table.

4. Students should switch tasks and repeat the process.

5. Review the questions on the student sheet. If students need help, explain to them that in this model the rice represents the material in the collector wafers and the safety pin represents the solar wind particles.

6. Ask: "Why were you blindfolded for this activity? How does this model solar wind analysis?" (Students may suggest that no one can see the solar wind particles. This model shows that further analysis with a mass spectrometer will need to take place.)

REFERENCES

Books:

Mohl, B. (1968) Auditory sensitivity of the common seal in air and water. J. Auditory Res., ch. 8, pages 27-38.

Grier, James, W. (1984) Biology of Animal Behavior. St. Louis, Times Mirror/Mosby.

World Wide Web:

http://www.umassd.edu/specialprograms/lloyd/leps.html
Moth Research

http://www-curator.jsc.nasa.gov/curator/genesis/Collectors.htm
Johnson Space Center Genesis Page

http://www.inhs.uiuc.edu/cwe/wwwtest/collect/HTML/d18.html#4
How to collect insects

http://www.inhs.uiuc.edu/cwe/wwwtest/collect/HTML/d16.html
Sifting, separating and extracting

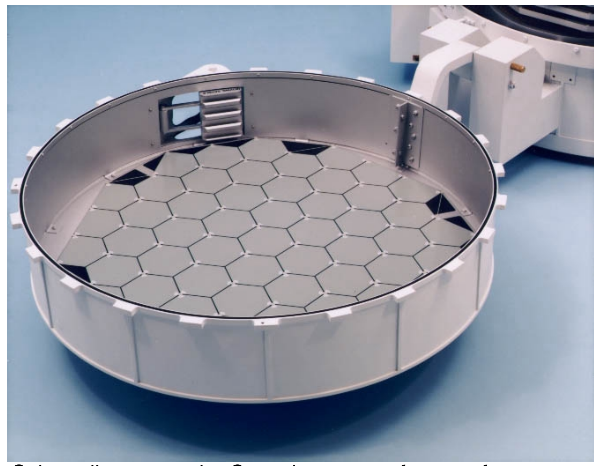
http://www.pitt.edu/~biohome/Dept/Nonframe/Faculty/luo.htm
Animal Senses

Dynamic Design: A Collection Process

Modeling Solar Wind Collection: A Sticky Situation

STUDENT ACTIVITY-PART 1

In this activity you will model how different materials collect different solar wind particles. In the Genesis spacecraft, the wafers will be made out of various materials in order to collect different elements and isotopes. All elements from atomic numbers 3 through 92 will be analyzed. Hydrogen and Helium make up the bulk of the sun and will have to be "filtered out." In this first activity, you will throw projectiles onto different surfaces and determine which of them embed.



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Solar collectors on the Genesis spacecraft are wafers attached to a frame.

PROCEDURE

1. Solar collectors on the Genesis spacecraft are wafers attached to a frame. The wafers are made of different materials based on the type of solar wind particles that the scientists plan to capture and analyze.

2. Based on the materials that will be used in this activity, predict which projectiles will embed into each surface, which will stick and not embed, and which will neither stick nor embed. Solar wind particles will be embedded into the collectors. In your small group, operationally define "embed." The following grid may be used to help make the predictions. Label projectiles and surfaces used in this data table:

Key: E = projectile will embed S = stick N = not stick ?= unsure

PREDICTION DATA TABLE					
		Projectile 1	Projectile 2	Projectile 3	Projectile 4
Surface 1					
Surface 2					
Surface 3					
Surface 4					

3. Which variables should be controlled in this experiment? How will you control the variables?

4. Obtain the materials and construct the projectiles if needed. Then test each of your projectiles against the various surface materials.

5. Record your results in the following table. Make sure to complete three trials per projectile per surface.

Key: E = projectile embedded S = projectile stuck N = projectile did not stick or embed

Surface:

Surface 1	Projectile 1	Projectile 2	Projectile 3	Projectile 4
Trial 1				
Trial 2				
Trial 3				

Drawings and Additional Observations:

Key: E = projectile embedded S = projectile stuck N = projectile did not stick or embed

Surface:

Surface 2	Projectile 1	Projectile 2	Projectile 3	Projectile 4
Trial 1				
Trial 2				
Trial 3				

Drawings and Additional Observations:

Key: E = projectile embedded S = projectile stuck N = projectile did not stick or embed

Surface:

Surface 3	Projectile 1	Projectile 2	Projectile 3	Projectile 4
Trial 1				
Trial 2				
Trial 3				

Drawings and Additional Observations:

Key: E = projectile embedded S = projectile stuck N = projectile did not stick or embed

Surface:

Surface 4	Projectile 1	Projectile 2	Projectile 3	Projectile 4
Trial 1				
Trial 2				
Trial 3				

Drawings and Additional Observations:

6. Complete the following questions:

a. Which surface had the most projectiles that were embedded?

b. Why do you think this is so?

c. What may have caused your results to differ from those of another lab group?

d. What would you suggest next time to have more particles embed?

e. If you were going to design wafers to collect the greatest number of different projectiles, which surface would you choose? Why?

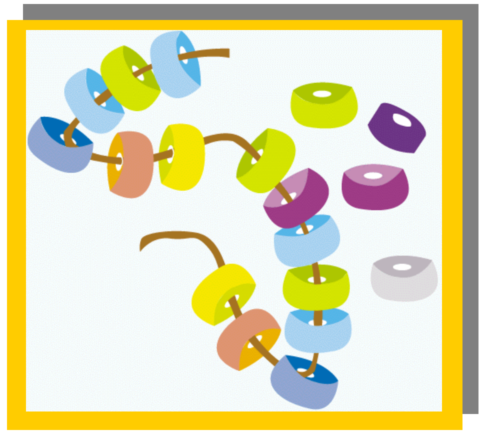
f. If you were going to design boxes to collect specific projectiles, which would you choose?

Dynamic Design:
A Collection Process

Modeling Solar Wind Collection: Better Beads

STUDENT ACTIVITY-PART 2

In this activity, you will model the collection process. The beads will represent the collection wafers and solar wind. The beads representing wafer materials will be taped onto a background. Solar wind beads will be thrown against the wafer. After some time under the black light, the beads will change color. You will discover what elements and isotopes were obtained and problems that may result in the collection process.



PROCEDURE:

1. Obtain several beads, wafer hexagon, and double-sided tape from your teacher.
2. Trace the hexagon pattern from this student activity onto a sheet of paper. Cut and apply the tape to the hexagon and place the beads on the hexagon.
3. Place your wafer (hexagon) with beads next to the wafers from the rest of the class' wafers to form a mini-collector array.
4. Take several other beads from the “solar wind” container and throw them at the collector array.
5. Take your collector wafer to the ultraviolet light station. The ultraviolet light will allow you to see some of the solar wind particles. Note that there are some contaminants located on some of the wafers. Record qualitative observations in the results box below.

Safety Note:

Do not look directly at the black light. UV exposure can cause eye and skin damage.

Results:
Drawing of wafer beads under blacklight for step 5:

Questions:

1. Were there any surprises? Did some materials **collect** solar wind better than others?

2. Explain your answer to Question 1.

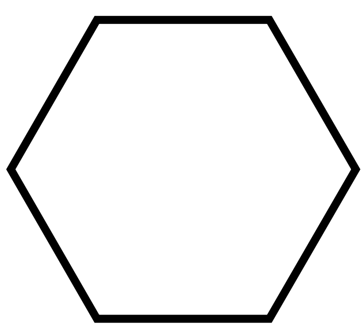
3. In what ways is this model similar to the actual Genesis mission solar collectors?

4. In what ways is the model different than the actual Genesis mission solar collectors?

5. What were some of the problems you encountered when trying to detect the beads that were embedded into the wafer?

6. How would you solve some of these problems?

Trace the hexagon below. Onto a sheet of paper, glue or use two-way tape to place the beads representing the material you chose for your wafer.



Background hexagon

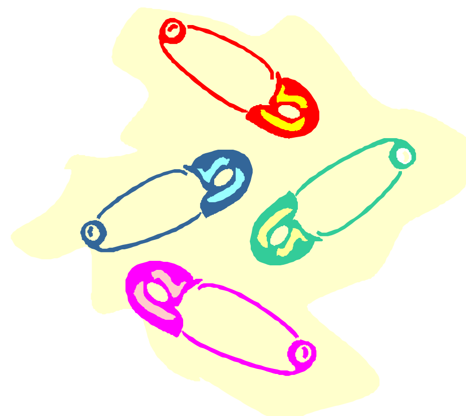
Dynamic Design:
A Collection Process

Modeling Solar Wind Collection: Invisible Analysis

STUDENT ACTIVITY–PART 3

In this activity, you will learn that the model in "Better Beads" was deficient in the fact that the analysis was visible. The analysis of the solar wind particles on the wafers requires more than meets the eye. The analysis is completed by analytical instruments, not human observation.

PROCEDURE



1. Gather materials as specified by your teacher. Your goal will be to pick out the safety pins from the bowl of rice while blindfolded.
2. Each person should predict the number of safety pins they will pick out in one minute.
3. Ask one group member to put the blindfold on and another member to keep time. The blindfolded student will have one minute to pick out as many safety pins as possible. Make a data table that includes each person, predictions, actual number of pins picked out, and difference between actual and predicted pick-ups. Record results in a data table.
4. Repeat this process two more times.
5. Switch roles and repeat the process.

RESULTS

Trial	Prediction	Results
1		
2		
3		

QUESTIONS

1. Identify the parts of this model. What did the rice represent? What did the safety pins represent?

2. Why were you blindfolded?

3. How does this model solar wind collection?

Dynamic Design: A Collection Process

Continuous Collecting

STUDENT TEXT

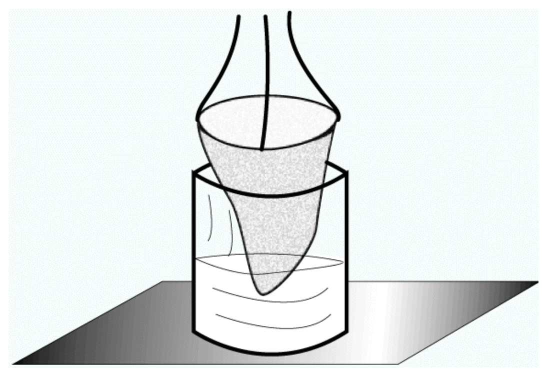
DATA COLLECTION

Data are the facts and figures from which conclusions may be drawn. There are different types of data that can be collected. One type is **continuous data** or a measurement that involves **quantitative** (how much) observations. An example of continuous data would be measuring the temperature in a parking lot over time. Another type is **categorical data** or data that is obtained through **qualitative** (what it is) observations. An example of categorical data would be the types of cars found in a parking lot.

When conducting scientific investigations, scientists need to collect data to prove or disprove their **hypotheses**. There are many ways to collect data, ranging from surveys of people on the street to observations of organisms in the field. It is important to consider the purpose of the experiment when deciding how to collect the data. In most circumstances, the collection process involves **variables** that need to be controlled.

Why is it important to control variables in any scientific experiment? One also needs to consider potential sources of **bias** when collecting data. What is bias and how might it affect the data that is collected?

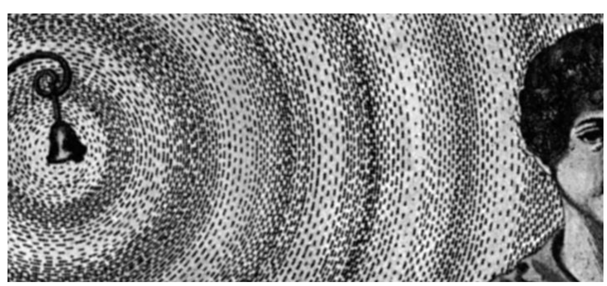
INSECT COLLECTION



Insect trap

Entomologists (scientists who study insects) have developed various techniques to collect insects. They use different capture techniques based on the type of insect they want to trap. There are different traps for flying insects, crawling insects, and those found mixed with ground cover. Scientists at the Lloyd Center South conduct surveys on moths in Massachusetts. Center director Mark Mello collects moths at night using four different methods, including mercury vapor light traps, portable blacklight traps, portable ultraviolet traps, and baiting trees. The first three methods use different types of light, whereas in the last method Mello paints a mixture of rotten bananas, beer, molasses, brown sugar, grape jelly, and rum onto tree leaves. The mixture mimics the odor of fermenting fruit, which attracts moths. A barrier trap is another device for catching flying insects. The windowpane is a barrier trap that consists of a piece of clear glass or plastic with a shallow trough filled with ethanol attached at the bottom. When the trap is hung across a path, in a flyway, or at the edge of the woods, flying insects crash into it. Those that drop after hitting the glass fall into the trough and are killed. Insects that crawl about on the ground can be captured in a pitfall trap. This can be constructed by placing a plastic cup partially filled with alcohol in the ground. Modifications can be made by adding bait such as rotting food or dry cereal to attract the crawler. Insects found in ground cover can be extracted by using devices that sift or separate the insect from the soil. Examples include a Berlese funnel, a separator box, or a kitchen sifter.

SOLAR WIND COLLECTION



Just as there are different types of traps for collecting insects, there are different methods to collect solar wind. You have already read about the aluminum foil experiments that were used during the Apollo missions. This method was very good for collecting the noble gases. Another method of analyzing solar wind was used on Apollo 12 and 15. A solar wind spectrometer was used to compare the solar wind properties at the lunar surface with those measured in space near the moon. The Genesis spacecraft will have ultrapure wafers to collect bulk solar wind and an electrostatic concentrator that will reflect and focus a 1000 cm^2 cross section of solar wind particles onto a small target.

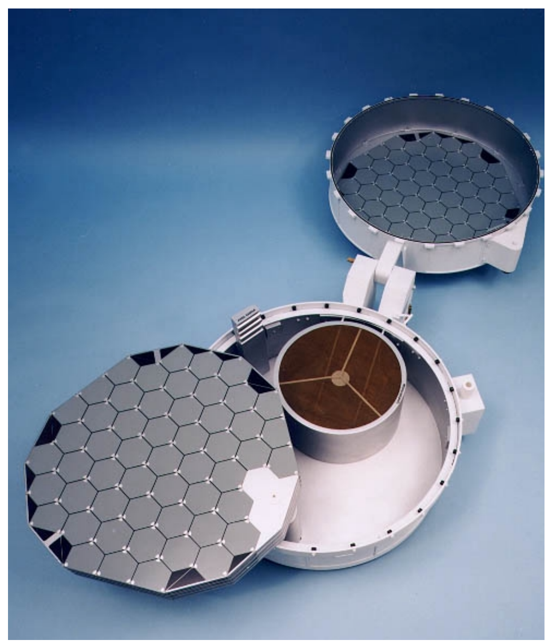
AN ANALOGY OF SOUND

Animals collect data constantly through their senses. Animals differ in the types of senses they have and the extent to which they are used. For instance, dogs have a good sense of hearing, yet other species are completely deaf. The Noctuid moth can detect the sound made by bats, but only as the presence or absence of sound. (They are tone deaf.)

Sound will be used in an analogy between the way animals hear and how the solar collectors on the Genesis spacecraft will collect solar wind. In vertebrates, hearing involves vibration of hair cells and fluid in the inner ear of mammals, birds, reptiles and amphibians and lateral line in fish. Mammals have the most advanced hearing sense of the vertebrates. Over 23 species including bats can hear high, ultrasonic pitches. Chimpanzees can hear up to 30 kHz while smaller animals like bats, mice, and shrews hear up to the range of 90 to 120 kHz. “Porpoises and seals may produce and hear underwater sounds up to around 180 kHz,” (Mohl 1968). Sound travels about five times faster in water than in the air. This is due to the water molecules being closer together than molecules in the air. Elephants can hear frequencies that are lower than humans (infrasonic). “The baleen whales can hear very low frequency sounds but have no echolocation. This enables the baleen whales to communicate over long distances, as the low-frequency sound has better propagation and wider scatter underwater,” (Luo, 1999).

In this analogy, all sound that exists in an environment will represent the solar wind. The animals that hear the sounds will represent the materials in the collectors on the Genesis Sample Return Capsule. Animals vary in their ability to hear the sound, just like materials vary in their ability to collect elements of solar wind. The materials used in the collector wafers will capture and hold the solar wind samples. This material will vary depending on the element or elements to be captured. How is the sound analogy an effective way to relate to solar wind collection on the Genesis spacecraft? In what ways does this analogy fall short of an accurate portrayal of Genesis solar wind collection?

The materials used in the collector wafers must be pure enough so that the ratio of solar wind particles to impurities is greater than 100 to 1 (less than 1%). The materials must also be clean enough so that for any given element, the surface contamination will be less than would be expected for the two-year collection period. The materials used must also allow scientists to analyze the results with the desired technique. Finally, the correct materials must be used for different elements. For instance, if the scientists are trying to analyze carbon, they would want a wafer material to be something other than carbon. Based on extensive testing, specific materials will be used in constructing the collector wafers. Silicon wafers will be used to collect most elements and isotopes. Aluminum will be used for the noble gases. Chemical vapor deposit (CVD) diamond will be used for oxygen, nitrogen, and other light elements. Diamond, gold/platinum, germanium, and other substances will be used for alkali elements, radioactive elements, and as alternates for all measurements. Materials such as sapphire, and combinations such as diamond on silicon, silicon on sapphire, aluminum on sapphire, and gold on sapphire will also be used.



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Collector Array

Data collection is important in all areas of science. From entomology to cosmic chemistry, scientists use various collection techniques in order to have the data necessary to answer their research questions. Data collection is just one step in the process. According to the National Science Education Standards students of science should, “Design and conduct a scientific investigation (e.g., formulate questions, design and execute investigations, interpret data, synthesize evidence into explanations, propose alternative explanations for observations, critique explanations and procedures)." Once the isotopic data has been returned from the Genesis mission scientists will spend years interpreting this data and using this evidence to have a clearer picture of the solar system in which we live.