Mission 14
Final Spacecraft and Lander Design

Exobiology Instruments and a Final Analysis

Overview

In mission 14, students redesign their original spacecraft and landers from mission 5, improving them based on what they have learned throughout these missions. In mission 14.1, students begin to understand payload constraints and mission limitations when they are allowed to include only three life detection instruments as part of their final spacecraft-lander. In mission 14.2, students receive simulated data from the successful deployment of their spacecraft and landers to the extraterrestrial landing sites. Based upon these communications, students issue a statement on the presence or absence of life at their landing sites.

Notes

In mission 13, students saw a spacecraft and lander that actually went to Mars to look for life. Comparative planetologists and exobiologists work closely with spacecraft engineers to optimize a spacecraft-lander system's scientific performance while minimizing its weight and expense. Scientists must understand as much as possible about each instrument they use-how it works and what information it will send back. This and the anticipation of what can be learned from information sent back to Earth are key components in successful spacecraft design.

Mission 14.1
Materials

For Each Student

- Pages from mission 5:
- “Initial Spacecraft Design” worksheet
- “Designing a Spacecraft and Lander” optional directions
- “Landing Site Environment” data sheet
- “Design Conference” worksheet
- “The Viking Lander”
- “The Final Design” worksheet
- Pencil

Getting Ready

1. Assemble the pages from mission 5, “Initial Spacecraft and Lander Design.”

2. Copy the “The Final Design” worksheet for each student.

Classroom Action

1. **Preliminary.** Have students regroup into their six landing-site teams from mission 5. Hand out “The Final Design” worksheet to each student. Return to each student their pages from mission 5.

2. **Discussion.** Tell the class that because they have learned much about searching for signs of life on alien worlds, they should be able to improve the designs of their composite spacecraft and landers from mission 5. Remind teams that they are in charge of a mission to detect life or signs of life at their landing site. They must prepare a spacecraft and lander with instrument that will gather information that they will use to decide whether life is present at their landing site. Explain that they cannot send any people because of cost and weight constraints! Each test must be automated. In addition, each spacecraft-lander system is limited to a total of three instruments. This will force students to choose the best and most reliable tests for their landing sites. (There are no “right” answers for this selection of tests.) Make sure students consider all their options! To do this they need a list:

    - Hold a class discussion and create a list on the chalkboard.

    - Have each team or student compile a list from their worksheets and notes from previous missions.

    - Hand out a copy of the provided “A Summary of Life Detection Tests” to each team or student.

    - Post “A Summary of Life Detection Tests” on a wall for class reference.

    - Make and show an overhead transparency of “A Summary of Life Detection Tests.”

    - The following life detection tests are used in this guide.

Table 14.1

Test	Test Question	Mission
Still camera photographs	Appearance of life?	1, 2, 4
Video camera to look for movement	Movement on site?	1, 2, 4
Microscopic camera	Appearance of life?	1, 2, 4, 6
Plate soil on nutrient gelatin	Growth in Petri dish?	3, 6
Identify water by its freezing point	Liquid water on site?	7
Identify water by its boiling point	Liquid water on site?	7
Expose soil to water	Movement in soil?	9
Burn or char a substance	Carbohydrate present?	10
Iodine test for starch	Starch present?	10
Ninhydrin test for protein	Protein present?	10
Expose Life Traps to air	Growth in Petri dish?	11
Analyze gas production of soil	Graph indicates life?	12

3. **Activity.** Have the teams develop and improve the instruments that conducted the experiments and tests throughout their missions. Explain that the instruments must carry out their intended tasks without human intervention. The instruments must be realistic, given current technology. Tell students that they may develop a different type of life detection instrument for their spacecraft or lander if they can come up with a better test than any that were discussed in the missions.

   All plans should be reviewed by the team and it should decide which instruments to include on their spacecraft and lander. Toward the end of this activity, encourage students to complete the overall designs of their spacecraft lander systems. Have each team hand in its completed designs for review. Post them in a display.

   Teacher's Note: *There are special considerations for the Venus sites. On the surface, Venus is like a pressure cooker. No soil tests are possible in the atmosphere. However, soil samples can be tested inside an insulated and refrigerated lander (if the lander is equipped with a scooping device). Also, if any solid material is collected from the air, it can be tested (inside the lander) by charring, Ninhydrin, or iodine, or by analyzing its gas production when submerged in water. If a cold plate is exposed to the atmosphere, liquids might condense upon it; these could be tested for water and life.*

Mission 14.2
Materials

For Each Team

- 1 “Instrument Results” data printout
- Completed spacecraft-lander design from mission 14.1

For Each Student

- “Interpretation of Data” worksheet
- “Summit Notes” worksheet
- Pencil

Getting Ready

1. Make one copy of each “Instrument Results” data sheet. Cut the sheets in half so each team receives only the data for its landing site. There is one data printout provided for each of the six landing sites.

   (optional) Blank “Instrument Results”sheets are also provided if you wish to create the data for your students.

2. Review each teams' spacecraft-lander design and prepare the “Instrument Results” data printout for each teams' instruments. Each printout contains the results of all 12 life detection tests used in this guide. Because each team is limited to three tests, you must black out the lines on the printouts that correspond to tests not performed. If a team included a novel instrument or a test of their own design, be creative and make up the results. Malfunctions are always possible!

3. Copy the worksheets “Interpretation of Data”and “Summit Notes” for each student.

Classroom Action

1. **Discussion.** Reassemble the six student teams. Hand back their spacecraft-lander designs from mission 14.1. Tell students that, after many months of interplanetary travel, their spacecraft and landers have all made it to their landing sites. Responses have just been received from their instruments. Most test results are given as “positive” or “negative.” In some cases, if there was no clear positive or negative result, are listed as “inconclusive.” Note that a “positive” result in the “analyze gas production of soil” test is listed as a “quick release” or a “slow release” of gas, while a “negative” result is listed as “no release of gas.”

2. **Activity.** Hand out the “Interpretation of Data” worksheet to each student and the appropriate “Instrument Results” data printout to each team. Tell each team to consider the instrument data and decide whether or not life was detected. This conclusion should not be obvious, and team members may disagree. This is a complicated problem in logic. Students must decide whether a “positive” result, such as growth on a Petri dish exposed to the air, is caused by microscopic extraterrestrial life; or by a contamination; or by soil blowing into a container, which could have looked like “growth” to a camera; and so on! Some results may appear contradictory. Encourage students to think; there are no “right” answers. After the team reaches a conclusion, they should record their data and write down their conclusions for the upcoming “Summit Meeting.” Each team should choose at least three presenters for this meeting.

3. **Activity.** Hand out the “Summit Notes” worksheet to each student. Hold the “Summit Meeting.” Invite teams to share their findings. Designate a strict time limit for presentations and cut students off when their time is up to give the sense of a high-pressure science meeting. Tell students to complete their “Summit Notes” worksheets as the delegations make their presentations.

4. **Homework.** Have students write a press release for their local papers or science institutions.

Going Further

Activity: All the Data!

Give each team the entire “Instrument Reading” data printout for their landing site, with the results of all 12 tests instead of just **3.** Ask students if the extra data changes their opinions or conclusions. In deciding what tests to include, do they feel that they chose wisely or poorly? Would they change anything if they could design their spacecraft lander system again?

Give each student the entire data printouts for all six sites. Tell students that two sites show signs of alien life! Have them determine which ones. Have students rank each site, from “most likely for life” to “least likely for life”; or have students compare the results of the same test at all six sites.

Research: Analogous Earth Environments

Have each team research an Earth location that is analogous to their extraterrestrial landing site. Then have them design experiments to conduct on Earth that might help clarify the results from their spacecraft and lander. What could they expect to find at their Earth site that would indicate the presence of life? Would some of the tests yield inconclusive results?

Table 14.1

Landing Site	Earth Equivalent
# 1—Mars, Utopia Planitia Desert	Desert valleys of Antarctica or Death Valley, California
# 2—Mars, Olumpus Mons Volcano	Summit of Mauna Kea, Hawaii or Summit of Mt. Penatuba, Philippines
# 3—Mars, North Pole	Great ice sheet of Antarctica
# 4—Venus, Aphrodite Terra Continental Plate	None
# 5—Atmosphere of Venus	None
# 6—Venus, Rhea Mons Volcano	None

Activity: Now Where Do We Go?

Ask students to propose a mission for NASA. Have them decide where they should go, how they should get there, and what they should look for.

What factors will give the mission the best chance to detect the presence of life? Why?

Give a lecture entitled “How to Write a Grant Proposal,” and discuss how scientists (and science writers!) often get money to do their work. Have each team write a grant proposal and submit it to a review panel of their peers. Give some Monopoly money to the panel and have them give out their “awards” to the most worthy projects. Require written justification of their choices!

Discussion: Is It Worth It?

Ask students how they feel about NASA missions to Venus and Mars. Are they worth the cost? Could the money be better spent? What kind of spin-offs might benefit mankind? How would the discovery of alien life affect us as a people?

These topics may be handled as debates or as simulated “talk shows” with students playing the roles of experts in the detection of alien life.

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Interpretation of Data-Teacher’s Key

The following answers are based upon a knowledge of the incoming data from all 12 tests. Because students are limited to only three pieces of information, their conclusions and reasoning may vary.

1. **Mars, Utopia Planitia Desert.** The data suggest that there is no life here. The only positive test was the detection of movement after the addition of water to soil. Perhaps particles in the soil are buoyant and are floating around. The quick release of gas from soil is what we would expect from a nonliving chemical reaction. With so many other tests being negative, it is logical to conclude that there is no life here.

2. **Mars, Olympus Mons Volcano.** Things growing on nutrient gelatin, in the Life Traps or in soil, suggest that there is life here. (These may be two different ways of showing the same thing; something in the soil that also gets blown into the air may be giving this positive result.) However, many negative outcomes of direct tests for the components of life are too compelling to be ignored. A best guess based on all the data: there is no life here.

3. **Mars, North Pole.** The most logical conclusion is that there is no life here. Water is present; however, its mere presence does not prove that life exists here. The quick release of gas from soil is what we would expect from a nonliving chemical reaction. Many other negative outcomes make it logical to conclude that there is no life here.

4. **Venus, Aphrodite Terra Continental Plate.** After scooping the soil sample into the lander (and drawing cooled air over Life Traps in the lander), several interesting positive results are seen. The test found water and growth of something in the air. The

tests for organic materials are negative, however, as is a test for growth of objects in a soil sample. The most logical conclusion is that there is no life here.

5. **Atmosphere of Venus.** This example has been crafted to give the most promising indications of life of the six sites. Water was detected. Airborne particles tested positive for carbon, protein, and starch; they slowly released gases when given nutrients. Growth was seen in a Life Trap. All this is consistent with the presence of life as we know it. A conclusion based only on these tests would have to be a tentative one, but the evidence suggests that there is life here.

6. **Venus, Rhea Mons Volcano.** After scooping the soil sample into the lander (and drawing cooled air over Life Traps in the lander), several interesting positive results are seen. Water (which was vapor before it was sampled) is present. Something appeared to grow in the Life Trap. The quick release of gas by soil inoculated with a nutrient is what we would expect from a nonliving chemical reaction. With so many other tests being negative (and considering the environment), it is logical to conclude that there is no life here.