The Cassini Robot

LESSON 5

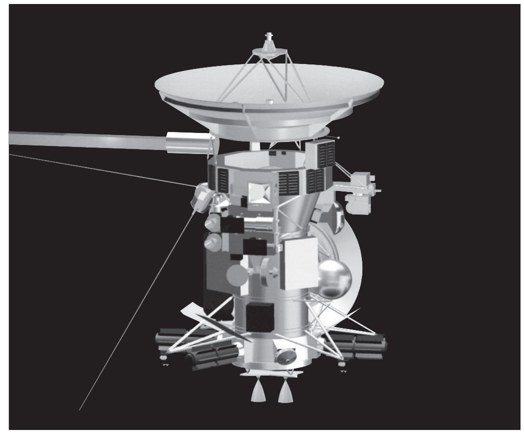
3–4 hrs

MEETS NATIONAL SCIENCE EDUCATION STANDARDS:

Unifying Concepts and Processes
• *Form and function*

Science and Technology
• *Abilities of technological design*

Students begin by examining their prior notions of robots and then consider the characteristics and capabilities of a robot like the Cassini–Huygens spacecraft that would be sent into space to explore another planet. Students compare robotic functions to human body functions. The lesson prepares students to design, build, diagram, and explain their own models of robots for space exploration in the Saturn system.



A computer-generated rendering of Cassini–Huygens.

PREREQUISITE SKILLS

Drawing and labeling diagrams
Assembling a spacecraft model
Some familiarity with the Saturn system (see Lesson 1)

BACKGROUND INFORMATION

Background for Lesson Discussion, page 122
Questions, page 127
Answers in *Appendix 1*, page 225
56–63: The Cassini–Huygens Mission
64–69: The Spacecraft
70–76: The Science Instruments
81–94: Launch and Navigation
95–101: Communications and Science Data

EQUIPMENT, MATERIALS, AND TOOLS

For the teacher

Photocopier (for transparencies & copies)
Overhead projector
Chart paper (18" × 22")
Markers; clear adhesive tape

For each group of 3 to 4 students

Chart paper (18" × 22")
Markers
Scissors
Clear adhesive tape or glue
Various household objects: egg cartons, yogurt cartons, film canisters, wire, aluminum foil, construction paper

Materials to reproduce

Figures 1–6 are provided at the end of this lesson.

FIGURE	TRANSPARENCY	COPIES
1		1 per group
2	1	
3	1	1 per student
4		1 per group
5	1	
6 (for teacher only)		

Background for Lesson Discussion

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The definition of a robot

(See Procedures & Activities, Part I, Step 2)

When asked what a robot is, students often come up with images of fictional devices like C3PO, who walks and talks with a British accent in the *Star Wars* movies. Another robot candidate is the one in *Lost in Space*. Such Hollywood-generated robots are shaped more or less like humans and they communicate like humans. Students tend not to think of washing machines or spacecraft like Voyager or Cassini as robots — but these are classic examples of what is meant by "robot."

Definition of a robot: A programmable and/or remotely controlled machine, capable of performing or extending human tasks, often in environments that are too hazardous for humans or in situations that are too repetitious or tedious for humans.

Robots like Voyager, Pathfinder, and Cassini are extensions of human senses, not only in terms of operating in a remote, hostile environment like outer space, but also in terms of sensing in ways that humans cannot — e.g., detecting magnetic fields, or "seeing" in the infrared or ultraviolet portions of the electromagnetic spectrum (see the *Appendices*).

In this lesson, the natural tendency for students to liken robots with humans is channeled toward an analogy between the functions of spacecraft components and those of human body parts. This approach allows class discussion around the concept of form and function (Part II, Step 5).

According to the NRC National Science Education Standards, "form" and "function" are complementary aspects of objects, organisms, and systems in the natural and designed world. The form or shape of an object or system is frequently related to use, operation, or function. Function frequently relies on form. Students should be able to explain function by referring to form and explain form by referring to function.

For example, a spacecraft's antenna is shaped like a dish to help receive radio waves, or a probe may be shaped like a cone so that it will more easily travel through an atmosphere, or a spacecraft instrument may be hung on a boom to allow it to directly sample properties of the environment without interference from the spacecraft.

Lesson Plan

Part I: What Is a Robotic Spacecraft?

1. Arrange students in groups of four or fewer. Ask them to record a group definition of a robot on a piece of chart paper. One person in the group should record the definition and another should report the definition to the whole class.

2. Have each group post and report their definition of a robot. Record the key words from the definitions on the blackboard. (See *Background for Lesson Discussion*.)

3. Inform students that a robot designed to explore space is called a spacecraft.

4. Ask students what capabilities or features they would recommend for a robot that would be sent into space to explore another planet. List their responses for later comparison. If needed, guide students by suggesting an analogy with human capabilities, such as movement, senses, communication, thinking, etc.

5. Give each group a copy of *Spacecraft Components* (Figure 1). Have students work in groups to discuss and predict the humanlike function of each of the parts.

6. Instruct students to cut out the different spacecraft components and then arrange and attach them to a sheet of paper in a logical configuration.

7. Instruct students to label each of the spacecraft components with its name as well as the predicted humanlike function. Have the students give their robot a name using one of the scientists from the time line in Lesson 4 or one of the moons in Lesson 2.

8. Have the students in each group attach their individual diagrams to a piece of chart paper and display it to the whole class.

9. Quickly review the various student designs. Ask students if they would like to share the rationale for their designs.

10. Ask students what they would like to know about spacecraft. List their questions on chart paper.

Part II: Making Connections to Cassini

1. Introduce the Cassini spacecraft by displaying and reading a transparency of *Cassini: "Gee Whiz" Facts* (Figure 2).

2. Give each student a copy of the *Cassini Component Functions Table — for Student Use* (Figure 3), and give each group a copy of the diagram entitled *Cassini: A Robot in Our Own Image — for Student Use* (Figure 4).

3. Display a transparency of the students' version of Figure 3, *Cassini Component Functions Table*. Tell the students that the function description in the table offers hints about how to determine a human analogy for each spacecraft component. Work with students to determine a human analogy for the first component or two listed.

4. Explain that the students will use their *Cassini Component Functions Table* to predict the function of each component. (See Figure 6 for the teacher's version of the *Cassini Component Functions Table*.) Members of each group should take turns drawing symbols on the *Cassini: A Robot in Our Own Image* diagram. Students should begin with the skeleton symbol shown on *Cassini: A Robot in Our Own Image — for Teacher Use* (Figure 5) and move clockwise around the spacecraft.

5. After student groups have completed the *Cassini: A Robot in Our Own Image* diagram with their symbols, display a transparency of the completed diagram, *Cassini: A Robot in Our Own Image — For Teacher Use*. Using the transparency, review the form and function of each major part of the Cassini robot.

6. Discuss the students' discoveries about the Cassini spacecraft in light of what they wanted to know about a robotic spacecraft. Guide students to reflect on the mission the Cassini spacecraft is designed to do, and on how the key components of Cassini's technological design will enable it to carry out that mission. Discuss whether or why each component is essential to the success of the mission.

Part III: Assessment

1. Arrange students in groups of four or fewer.

2. Instruct the groups to identify and record the robotic spacecraft components necessary to explore their favorite location in the Saturn system. Ask them to consider how and what the robot will explore. Will it land on a surface of a moon? Will it orbit a moon? Will it fly over the rings? Will it probe into Saturn's or Titan's atmosphere?

3. Student groups should design and build models of their spacecraft using an assortment of objects such as yogurt and egg cartons, wire, film canisters, construction paper, and aluminum foil. The model robot should have all the components to fulfill critical functions.

4. Student groups should diagram their models and each provide a table on chart paper that lists the critical spacecraft components and their functions.

5. Have student groups present their robotic spacecraft models to the class. Students should review and describe their process of technological design by identifying their missions, and how the spacecraft will fulfill those missions. Each group member should be responsible for explaining the form and function of at least one critical component.

Assessment Criteria

1. The students' tables have identified needed spacecraft components and function descriptions. Bare essentials include:

- *Bus framework*
- *Rocket motors for propulsion*
- *Antennas for communication*
- *Computer for processing data*
- *A scientific instrument such as a camera or a dust analyzer*

2. The model of the spacecraft corresponds to the components identified on the chart.

3. The diagram is labeled and accurately represents the model.

4. The presentation communicates the mission objective and the form and function of each component of the model spacecraft in a way that makes it clear how the spacecraft will fulfill its mission.

Part IV: Questions for Reflection

- How is a spacecraft a robot?
- Does the robot that you designed have humanlike capabilities?
- What would you hope to discover with your robot?
- What questions would your robot help scientists answer?

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Questions

These questions and their answers can be used to provide background for teachers or to explore prior knowledge and facilitate discussions with students. The answers are found in Appendix 1*, starting on page 225.*

The Cassini–Huygens Mission

56. Why are we sending a spacecraft and not people to Saturn?
57. What will the Cassini robot do?
58. What spacecraft have been to Saturn? How have we gathered information about Saturn up until now?
59. What will Cassini learn that we do not already know from Voyager and Hubble Space Telescope data?
60. Why care about the Cassini mission?
61. Why is NASA's mission to Saturn called Cassini?
62. How much does the Cassini mission cost? Who pays for it?
63. How long does it take to plan and carry out a mission like Cassini?

The Spacecraft

64. How big is the Cassini spacecraft?
65. How much wire is used in the Cassini spacecraft?
66. Is the Cassini spacecraft really all covered with gold?
67. Will the spacecraft use solar panels to provide power to the instruments on Cassini?
68. How does an RTG work? If it involves plutonium, is it dangerous?
69. How well can Cassini aim its instruments?

The Science Instruments

70. What kind of instruments does Cassini have? What do they do?
71. How well can the Cassini cameras see?
72. How do you know what color a planet or moon really is?
73. What does the Huygens probe do?
74. What kind of instruments does the Huygens probe have?
75. What happens to the Huygens probe after it lands on Titan?
76. If the Huygens probe were to sink, would there be any way to send information back?

Launch and Navigation

81. When was Cassini launched?
82. Which launch vehicle did Cassini use?
83. How much rocket fuel does Cassini carry in order to complete its mission at Saturn?
84. When does Cassini arrive at Saturn?
85. How long does the Cassini mission last?
86. Why does it take so long to get to Saturn?
87. Couldn't we get to Saturn faster if we flew directly to Saturn instead of wrapping around other planets?
88. What is gravity assist?
89. How close does Cassini come to Earth during its flyby?
90. Can we see the Cassini spacecraft from Earth during its flyby of Earth?

91. How far does Cassini travel from Earth to Saturn?

92. How fast does Cassini go?

93. How close does Cassini fly to Saturn's cloudtops?

94. What happens to Cassini after it completes the Saturn tour?

Communications and Science Data

95. How long does it take for a radio signal to travel between Earth and Saturn?

96. Has anything been learned from the failure of the high-gain antenna on the Galileo spacecraft that has altered the design of the Cassini's high-gain antenna?

97. How much power do Cassini's radio transmitters put out?

98. What is the Deep Space Network?

99. What if something goes wrong with the spacecraft? Do we have to wait an hour to learn about it?

100. How much science data will Cassini return?

101. How many pictures will be sent back from Cassini–Huygens?

Materials

Figure 1	**Spacecraft Components**
Figure 2	**Cassini “Gee Whiz” Facts**
Figure 3	**Cassini Component Functions Table — for Student Use**
Figure 4	**Cassini: A Robot in Our Own Image — for Student Use**
Figure 5	**Cassini: A Robot in Our Own Image — for Teacher Use**
Figure 6	**Cassini Component Functions Table — for Teacher Use**

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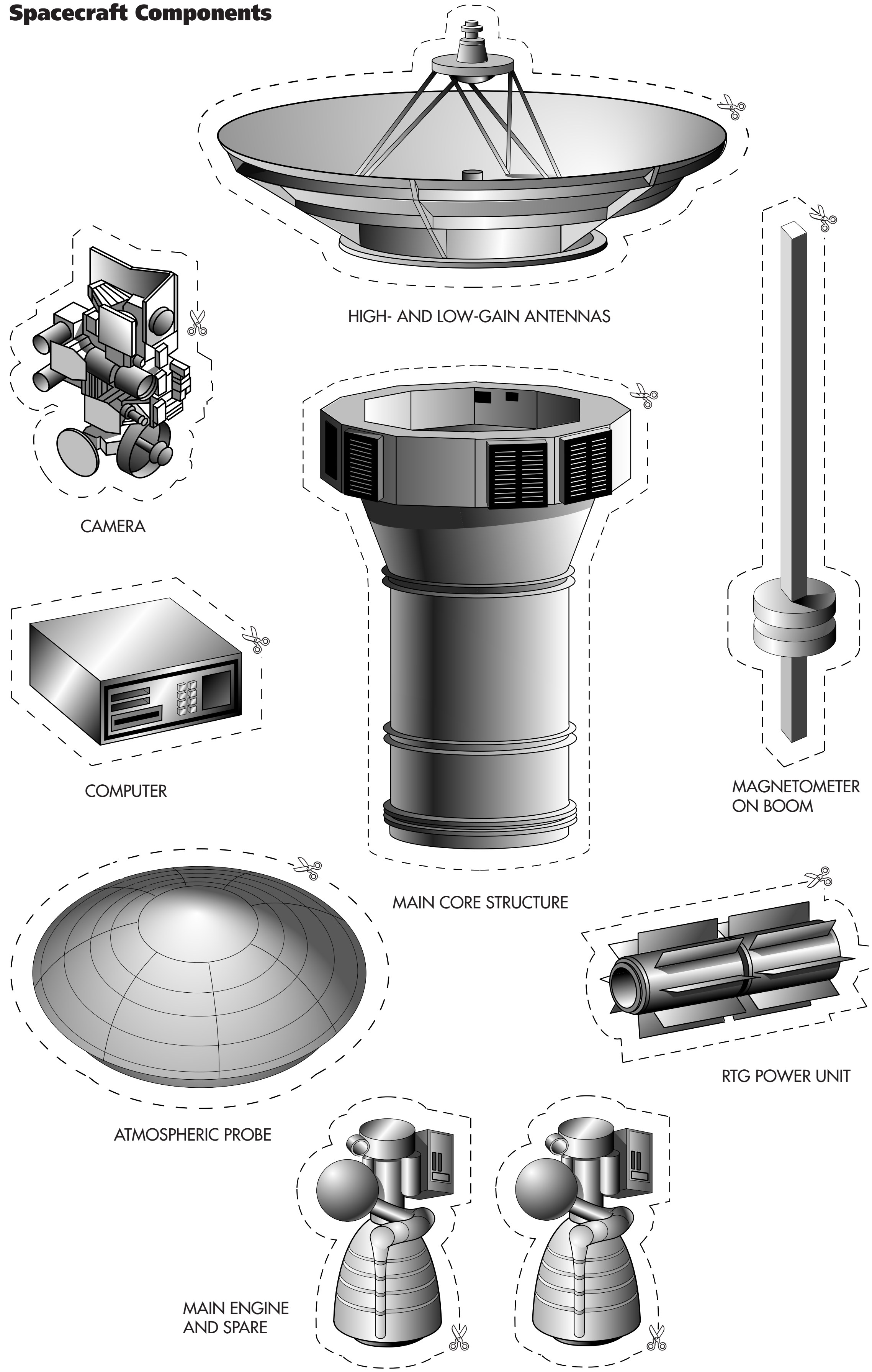
Figure 1

Spacecraft Components



Cassini "Gee Whiz" Facts

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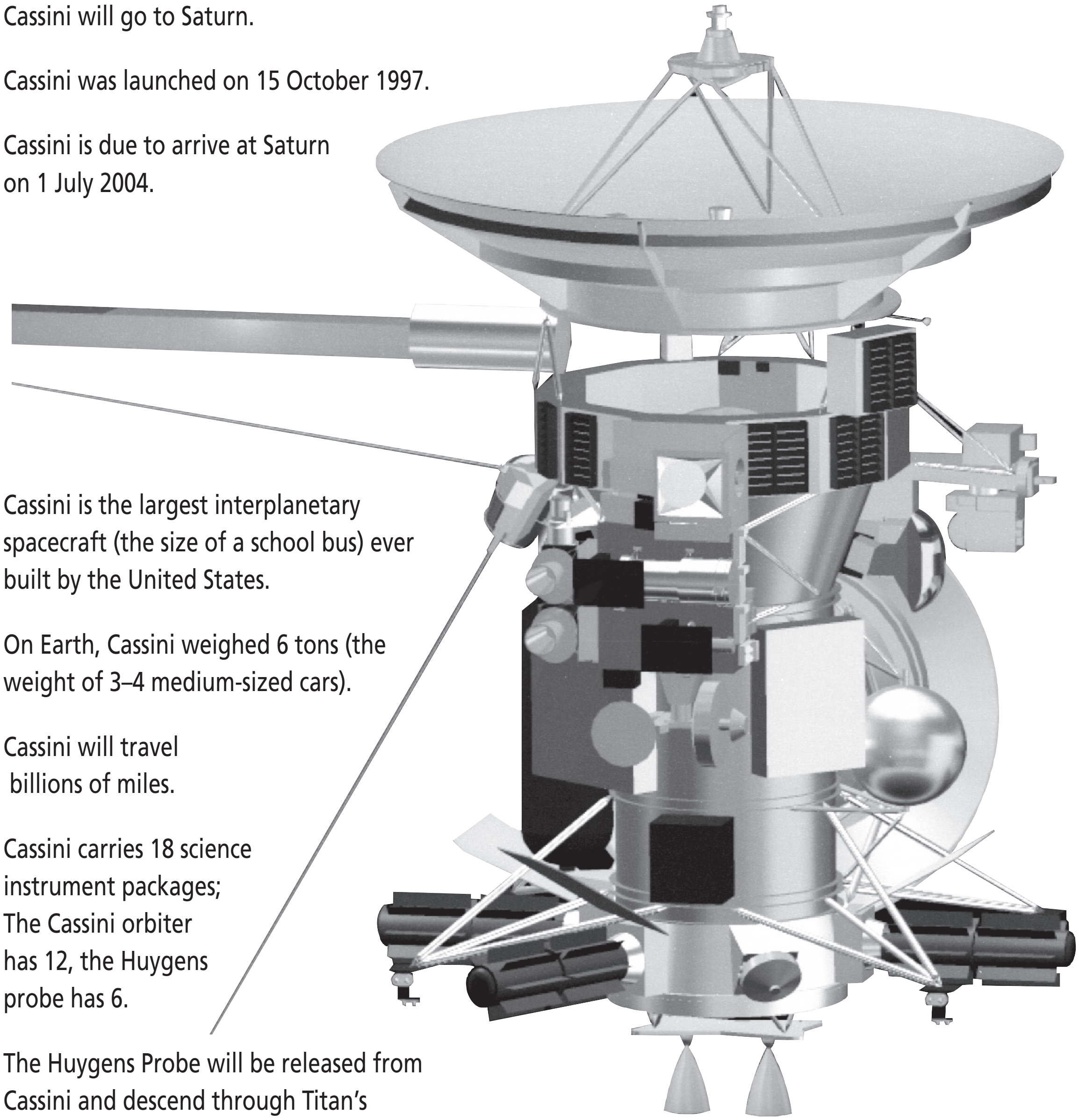
Figure 2



- Cassini will go to Saturn.
- Cassini was launched on 15 October 1997.
- Cassini is due to arrive at Saturn on 1 July 2004.
- Cassini is the largest interplanetary spacecraft (the size of a school bus) ever built by the United States.
- On Earth, Cassini weighed 6 tons (the weight of 3–4 medium-sized cars).
- Cassini will travel billions of miles.
- Cassini carries 18 science instrument packages; The Cassini orbiter has 12, the Huygens probe has 6.
- The Huygens Probe will be released from Cassini and descend through Titan's atmosphere.
- Cassini uses 7.5 miles of wiring. It serves as the spacecraft's "nervous system."
- Much of Cassini is covered with a gold-colored material for protection from extremes of hot and cold, and impacts of small space debris. This serves as Cassini's "skin" or "clothing."
- Cassini will reach a speed of up to 32 kilometers/second relative to Saturn. How fast is that in miles per hour?

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Figure 3

Cassini Component Functions Table — for Student Use

Use the descriptions in the column labeled "Function" to determine a possible human analogy for each Cassini component. Write your human part(s) or human need(s) in the blank column at the right.

Cassini Component	Function	Human Analogy
Spacecraft bus	The bus is the core structure (or framework) to which spacecraft components are attached. This is made out of aluminum, the same metal used in soft-drink cans.	
Orientation thrusters	These are small rocket thrusters (not the main engines) that are used for delicate maneuvers that rotate the spacecraft. This is useful for aiming instruments and pointing the antennae toward Earth.	
Main engines	Rocket motors provide thrust for moving the spacecraft in a particular direction or for braking maneuvers.	
RTGs	Radioisotope thermoelectric generators (RTGs) are the source of energy for Cassini's instruments and transmitters. RTGs convert nuclear energy to electrical energy. RTGs are not used for propulsion.	
Spacecraft cameras	Cameras and other science instruments "see" radio waves, infrared, visible, and ultraviolet light emitted or reflected by Saturn and its rings and moons.	
RPWS	The radio and plasma wave science instrument "listens" to different aspects of the environment around Cassini.	
Cosmic dust analyzer	The dust analyzer will sense dust particles that come into direct contact with the instrument.	
Magnetometer boom	This is an 11-meter-long "arm" extending from the spacecraft. There are instruments in the middle and on the end of it that are used to detect and measure magnetic fields.	
High/low gain antennas	Receivers and transmitters are used for communication between the spacecraft and Earth-based controllers. The antennae "hear" and "speak" for the spacecraft.	
Computers	Computers manage a variety of intelligent functions such as navigation and propulsion, storing information from scientific instruments, and sending information to Earth. There are over 40 different computers on Cassini.	
Huygens probe	This probe will be released from the "mother" spacecraft to descend through Titan's atmosphere to gather data on this mysterious moon of Saturn.	

Figure 4

Cassini: A Robot In Our Own Image — for Student Use

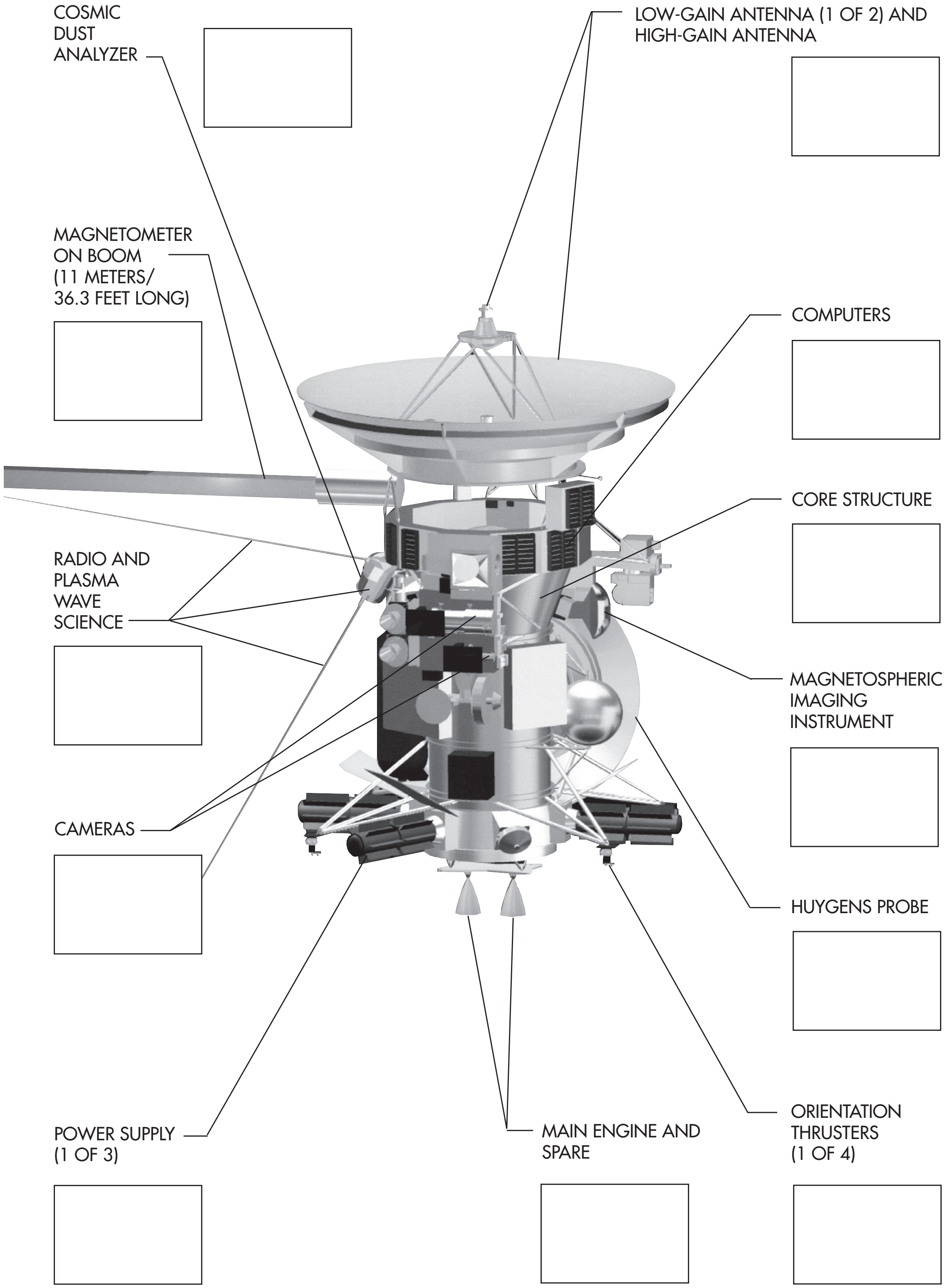

Figure 5

Cassini: A Robot In Our Own Image — for Teacher Use

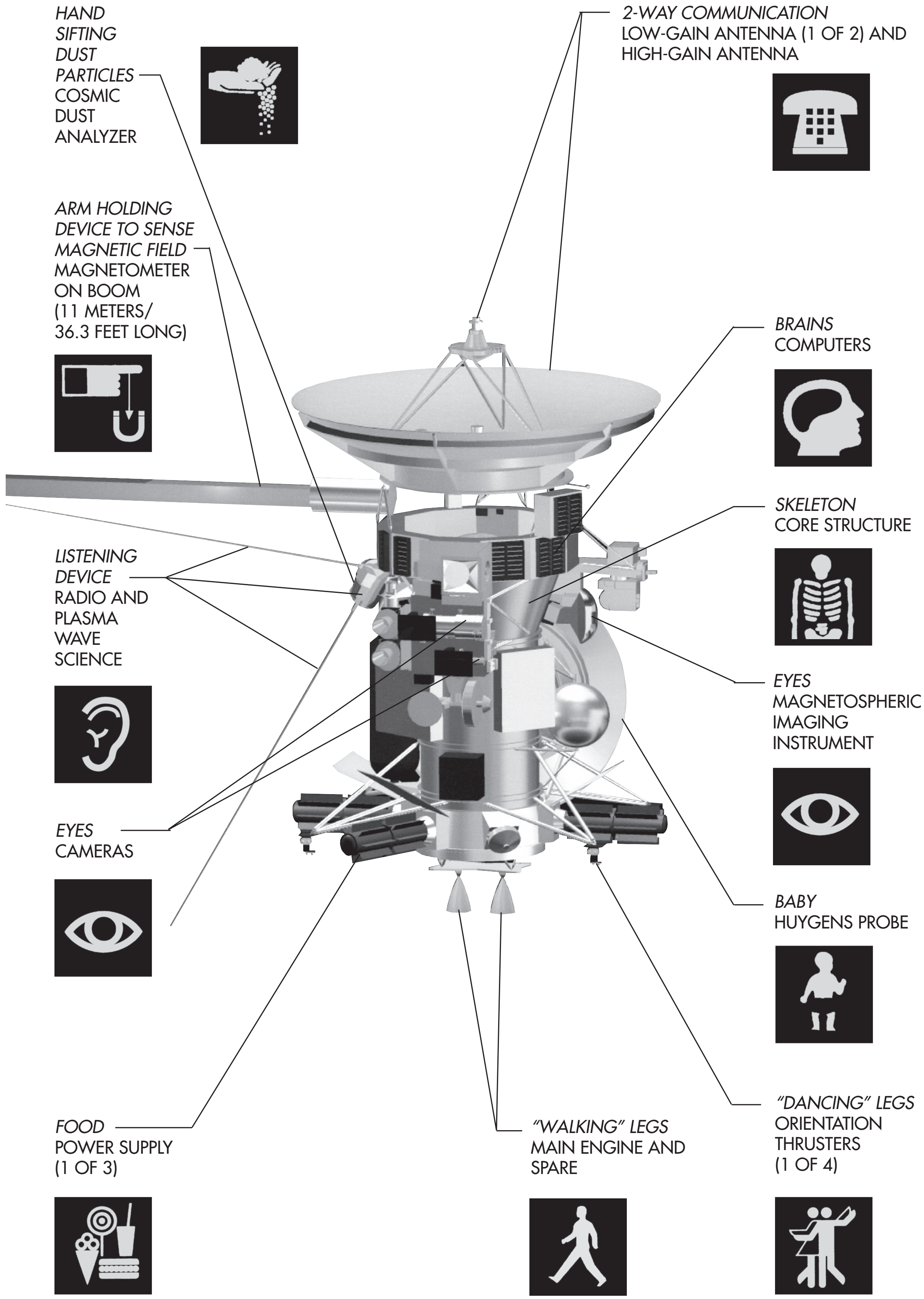

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Figure 6

Cassini Component Functions Table — for Teacher Use

Use the descriptions in the column labeled "Function" to determine a possible human analogy for each Cassini component. Write your human part(s) or human need(s) in the blank column at the right.

Cassini Component	Function	Human Analogy
Spacecraft bus	The bus is the core structure (or framework) to which spacecraft components are attached. This is made out of aluminum, the same metal used in soft-drink cans.	Body/torso/skeleton
Orientation thrusters	These are small rocket thrusters (not the main engines) that are used for delicate maneuvers that rotate the spacecraft. This is useful for aiming instruments and pointing the antennae toward Earth.	Dancing feet or legs
Main engines	Rocket motors provide thrust for moving the spacecraft in a particular direction or for braking maneuvers.	Walking/running feet or legs
RTGs	Radioisotope thermoelectric generators (RTGs) are the source of energy for Cassini's instruments and transmitters. RTGs convert nuclear energy to electrical energy. RTGs are not used for propulsion.	Food and drink
Spacecraft cameras	Cameras and other science instruments "see" radio waves, infrared, visible, and ultraviolet light emitted or reflected by Saturn and its rings and moons.	Eyes
RPWS	The radio and plasma wave science instrument listens to different aspects of the environment around Cassini.	Ears
Cosmic dust analyzer	The dust analyzer will sense dust particles that come into direct contact with the instrument.	Hands/tongue/nose
Magnetometer boom	This is an 11-meter-long "arm" extending from the spacecraft. There are instruments in the middle and on the end of it that are used to detect and measure magnetic fields.	Extended arm
High/low gain antennas	Receivers and transmitters are used for communication between the spacecraft and Earth-based controllers. The antennae "hear" and "speak" for the spacecraft.	Ears listening and mouth talking on the phone
Computers	Computers manage a variety of intelligent functions such as navigation and propulsion, storing information from scientific instruments, and sending information to Earth. There are over 40 different computers on Cassini.	Brain
Huygens probe	This probe will be released from the "mother" spacecraft to descend through Titan's atmosphere to gather data on this mysterious moon of Saturn.	Baby

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