ENRICHMENT 3

Saturn Poetry

Two poems are provided to analyze and discuss. Students can write their own poetry about Saturn and Cassini. See Figures 1 and 2 under "Materials" (page 213) for the full-size poem texts to reproduce.

Poem 1 — A Sense of Grandeur

TOPIC

Ask students to analyze and discuss the poem. The discussion can be approached from both the scientific and the poetic aspects. Use information from the *Questions and Answers* (*Appendix 1*) to stimulate students' questions and responses.

ACTIVITY

Have students write their own poems about Saturn, the rings, and the moons, and what Cassini might discover.

A Sense of Grandeur

A giant world of hydrogen,
One gaseous ball in space
A thousand Earths would fit within
This massive, ring-ed place.

This planet's av'rage density
You may indeed me quote
Is less than that of water, so
You see, it'd have to float!

And many moons do orbit round
This cold and golden sphere:
Eighteen of them, so far were found
With 'scopes afar and near.

And oh! the rings, such splendid things
Now thousands, not just one
Whose icy bits and boulders swing,
Reflecting rays of Sun.

What wonders 'wait our robot's eye
A billion miles away?
Such treasures will Cassini spy
With Saturn on display!

— Cherilynn Morrow, 1997

Poem 2 — Sensing the "Titan-ic"

DISCUSSION AND ACTIVITY

Ask students to analyze the poem. Have them write down a list of facts they have discerned from the poem, and also a list of questions they have. See *Background for Poem 2* for supplementary material that includes facts the students might discern, along with supporting notes to assist your discussion with the students and to answer questions that may arise from their studies of the poem. The *Glossary* provides help with technical terms.

Sensing the "Titan-ic"

I. What wonders 'wait our robot's eye
A billion miles away?
What treasures will Cassini spy
With Titan on display?

II. Old Huygens was the first to view
Great Saturn's largest moon.
In 1655 he knew
It kept with Kepler's tune.

III. Then Kuiper would at Titan peer
With "eyes" of infrared,
Detecting there an atmosphere —
Perhaps it wasn't dead!

IV. A prebiotic earthly place?
The thought of this astounds.
A moon, unlike our Old Man's face,
Where nitrogen abounds.

V. No Voyager or Pioneer
Could penetrate the haze
And make the surface features clear,
So now Cassini plays.

VI. Equipped with fancy radar "eyes"
We hope Cassini sees
The Titanscape o'er which it flies,
So veiled for centur-ies.

VII. A probe called Huygens also goes —
Cassini takes it there —
To fall through Titan's winds and flows;
To "taste" and "smell" the air.

VIII. When through the clouds
Our Huygens breaks
A camera wheel will turn,
And all the images it makes
Will serve our quest to learn.

IX. Will mountains drape the scenery?
Will brown organic goo?
Will hydrocarbon oceans be
A chilly ethane stew?

X. Feel you the curiosity?
The deep desire that's shown
When senses of humanity
Extend beyond the known?

— Cherilynn Morrow, 1997

EQUIPMENT, MATERIALS, AND TOOLS

For each student
Paper
Pencils

Materials to reproduce	
FIGURE	COPIES
1	1 per student
2	1 per group

ENRICHMENT

3

Background for Poem 2

Sensing the "Titan-ic"

- Ask students: Why do you think the poet chose this title? Is there more than one way of interpreting the title? For example, an interpretation might be that we are sensing Titan with Cassini–Huygens instruments (sensors), and sensing the monumental nature of exploring an unknown world. To support their interpretations, have students look up the definition of the word "titanic."

I. What wonders 'wait our robot's eye
A billion miles away?
What treasures will Cassini spy
With Titan on display?

II. Old Huygens was the first to view
Great Saturn's largest moon.
In 1655 he knew
It kept with Kepler's tune.

FACTS

1. Cassini is the name of the robotic spacecraft that will study Titan.

2. Titan is a billion miles away.

3. Titan is Saturn's largest moon, so Saturn must be a billion miles away as well, and Cassini must be going to visit the Saturn system.

4. Huygens discovered Titan in 1655.

5. Huygens knew of Kepler's Laws of orbital motion and applied them to learn of Titan's orbit.

SUPPORTING NOTES

- Saturn is actually a bit less than a billion miles away, but this is the correct order of magnitude. It is more like 0.87 billion miles = 870 million miles (1.4 billion kilometers) from Earth on the shortest straight-line path. However, the Cassini spacecraft will use gravity assists from Venus (twice), Earth, and Jupiter, and thus must travel nearly three times this far before reaching Titan. The trip will take nearly 7 years.

- Titan is Saturn's largest moon by far. Its diameter (5,150 kilometers) is more than three times greater than that of any other moon of Saturn. Ganymede, a moon of Jupiter, is the largest moon in the Solar System; Titan is second largest. Titan's diameter is about 25% larger than that of Earth's Moon. The distance around Titan is a little less than halfway around Earth.

- In spring 1655, Dutch astronomer Christiaan Huygens (HOY-genz) announced the first discovery of a moon of Saturn.

- "Kepler's tune" is an allusion to Kepler's original motivation to reveal the "music of the spheres" as he studied Tycho Brahe's extensive observational data looking for the planetary laws of motion he would eventually discover.

III. Then Kuiper would at Titan peer
With "eyes" of infrared,
Detecting there an atmosphere —
Perhaps it wasn't dead!

FACTS

1. Kuiper looked at Titan with a telescope and used a detector sensitive to near-infrared wavelengths. He discovered evidence of an atmosphere.

2. If Titan has an atmosphere, perhaps there could be life there.

ENRICHMENT

3

SUPPORTING NOTES

- Gerard Kuiper (KOY-per), Dutch-born American astronomer, was a pioneer in infrared astronomy. He was interested in finding out if any of the moons in the Solar System had an atmosphere. He studied the light reflected off the 10 largest moons, and in 1944 reported that Titan alone had an atmosphere that could be easily detected. Kuiper observed the spectral signature of methane on Titan.

- We can infer that Kuiper's observation was made no earlier than the 1930s because scientists only observed the sky in wavelengths of visible light until then. Today, we view the Universe across the entire electromagnetic spectrum — radio, microwave, infrared, visible, ultraviolet, x-ray, and gamma ray. See the *Glossary* for more information; the *Appendices* include an illustration of the electromagnetic spectrum.

- With a detectable organic compound like methane in the atmosphere, it was very natural to raise the question about whether life existed there, had existed there, or might yet exist there.

IV. A prebiotic earthly place?
The thought of this astounds.
A moon, unlike our Old Man's face,
Where nitrogen abounds.

FACTS

1. Titan might be like Earth before life evolved here ("prebiotic earthly place").

2. Titan is not at all like our Moon ("our Old Man's face" refers to the Old Man in the Moon).

3. Titan's atmosphere is abundant with nitrogen.

SUPPORTING NOTES

- A "prebiotic earthly place" would be rife with organic chemistry.

- Our Moon has no substantive atmosphere, and to our knowledge neither do any of the other 60 or so moons in the Solar System. Titan is unique and holds the possibility of teaching us something about the origin of life on Earth.

- Before Voyager 1's flyby of Titan in 1980, only methane and a few other simple hydrocarbons had been detected on Titan. Radio and infrared observations from Voyager 1 showed that Titan's thick atmosphere was roughly 90% nitrogen, plus the inert gas argon (at most 1%), and methane (a few percent). On Earth, methane is found bubbling out of marshes or swamps. Voyager 1 also determined that Titan's atmosphere is nearly 10 times deeper than Earth's atmosphere. At Titan's surface, the atmospheric pressure is about 60% higher than that of Earth.

V. No Voyager or Pioneer
Could penetrate the haze
And make the surface features clear,
So now Cassini plays.

FACTS

1. Voyager and Pioneer were spacecraft that visited the Saturn system.

2. These spacecraft could not see through the haze in Titan's atmosphere to discern the surface features.

3. Cassini now comes "into play" with greater capabilities than the earlier spacecraft.

ENRICHMENT

3

SUPPORTING NOTES

- The dates of the Saturn flybys of the earlier spacecraft are: Pioneer 11 in 1979, Voyager 1 in 1980, and Voyager 2 in 1981.

- Despite Voyager 1's close pass to Titan, the moon's surface features remained a mystery because spacecraft instruments could not see through Titan's thick haze. Scientists think this uniform haze layer is similar to the smog found over many cities on Earth.

- "Voyager" and "Pioneer" lend themselves to a play on words, suggesting that even these hearty explorers could not reveal the mysterious surface beneath Titan's haze — now there is the promise of Cassini. We are primed to anticipate what the Cassini mission might be able to do.

VI. Equipped with fancy radar "eyes"
We hope Cassini sees
The Titanscape o'er which it flies,
So veiled for centuries.

FACTS

1. Cassini is equipped with a radar imager that will be able to see through haze to measure the surface features of Titan.

2. "So veiled for centuries" signifies that although the moon was discovered more than three centuries ago, we have not had a chance to "see" Titan's surface until now. (Huygens discovered Titan in 1655, the Cassini–Huygens spacecraft arrives at Saturn and Titan in 2004 — 349 years later).

SUPPORTING NOTES

- Cassini's radar instrument is similar to the one used by the Magellan spacecraft in the early 1990s to peer through the thick clouds of Venus and map the surface terrain. Radar does not see like the human eye, but sends out radio waves that penetrate the atmosphere and reflect off the surface back to the spacecraft. Using careful techniques to time the radio waves' journeys to and from Titan, scientists can map surface features and determine their altitudes.

- Information from Magellan's radar imaging of Venus has been brought to the public quite dramatically in the IMAX film, *Destiny in Space*. On a 50-foot screen, the audience experiences what it would be like to fly over the mountains, volcanoes, craters, and chasms of Venus' terrain.

- The Cassini orbiter will make many close passes of Titan over the course of its four-year observational tour of the Saturn system (2004–2008). Indeed, gravity assist from Titan is essential to the capability of touring the system as extensively as is planned.

VII. A probe called Huygens also goes —
Cassini takes it there —
To fall through Titan's winds and flows;
To "taste" and "smell" the air.

VIII. When through the clouds our Huygens breaks
A camera wheel will turn
And all the images it makes
Will serve our quest to learn.

FACTS

1. The Cassini spacecraft carries a probe called Huygens (named for the moon's discoverer).

2. The Huygens probe will be released into Titan's atmosphere where its instruments will analyze ("taste and smell") the winds and composition of the atmosphere.

ENRICHMENT

3

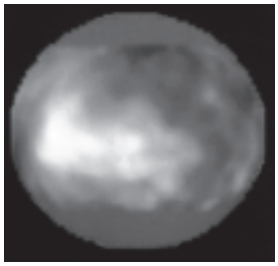
3. As the Huygens probe breaks through the cloud deck, a camera will capture pictures of the Titan panorama.

SUPPORTING NOTES

- The Huygens probe, supplied by the European Space Agency, carries a well-equipped robotic laboratory to observe the clouds, atmosphere, and surface of Titan. The probe is like a flattened, rounded cone that measures 2.7 meters (8.9 feet) in diameter at its base.

- As the probe enters Titan's atmosphere, it will begin taking measurements in the haze layer above the cloud tops. As it descends — first on a main parachute and later on a drogue chute for stability — various instruments will measure the winds, temperature, pressure, density, and energy balance in the atmosphere.

- Instruments on the Huygens probe will also be used to study properties of Titan's surface remotely — and perhaps directly, should the probe survive the landing. Many scientists think that Titan may be covered by lakes or oceans of methane or ethane, so the Huygens probe is designed to function even if it lands in liquid. If the battery-powered probe survives its landing, it will relay measurements from Titan's surface until the Cassini orbiter flies beyond the horizon and out of radio contact.



HST infrared image of Titan.

- A map of Titan was composed using infrared data from NASA's Earth-orbiting Hubble Space Telescope (HST). One of the HST instruments detects the Sun's infrared light that passes through the haze and reflects off Titan's surface. The map shows a bright area that may be a large land mass, and the surrounding areas might be mainly lakes or oceans of liquid ethane and methane. Scientists have fortuitously aimed Cassini's Huygens probe for a landing near the edge of the bright area.

IX. Will mountains drape the scenery?
Will brown organic goo?
Will hydrocarbon oceans be
A chilly ethane stew?

FACTS

1. We wonder what Titan's landscape will be like. Will it have mountains? Organic goo?

2. Will Titan have cold, liquid ethane oceans?

SUPPORTING NOTE

- Scientists' speculations about what Titan looks like are engaging. Imagine a world with misty orange skies, air with the same primary gas as Earth's air (nitrogen), a colorful surface that may look a little like the "Old Faithful" geyser basin in Yellowstone National Park, large hydrocarbon lakes with their surfaces rippling in the wind, and possibly an enormous ringed planet dimly visible through the high clouds. Perhaps the surface is covered with organic sediment ("organic goo") that has settled down from the clouds where organic chemical reactions are powered by the energy of sunlight. Titan temperatures hover around –292° Fahrenheit (–180° Celsius). At these temperatures, organic compounds like ethane and methane are in a liquid state ("chilly ethane stew"). On Earth, these chemicals are gases that bubble out of marshes or swamps.

X. Feel you the curiosity?
The deep desire that's shown
When senses of humanity
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ENRICHMENT

3

SUPPORTING NOTES

- Voyager 1 scientists had been so intrigued by what they might find at Titan that they were willing to sacrifice the possibility of sending the spacecraft on to other planets — the close flyby of Titan made it impossible to use Saturn's gravity to send the spacecraft on to Uranus and Neptune. Ask students — what would you be willing to sacrifice to explore an unexplored place?
- As the instruments of the Cassini orbiter and the Huygens probe peer at a never-before-seen landscape, they extend the senses of humanity to a world a billion miles away.

ENRICHMENT

3

Materials

Figure 1 **"A Sense of Grandeur"**

Figure 2 **"Sensing the Titan-ic"**

ENRICHMENT

3

Figure 1

A Sense of Grandeur

A giant world of hydrogen,
One gaseous ball in space
A thousand Earths would fit within
This massive, ring–ed place.

This planet's av'rage density
You may indeed me quote
Is less than that of water, so
You see, it'd have to float!

And many moons do orbit round
This cold and golden sphere:
Eighteen of them, so far were found
With 'scopes afar and near.

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Now thousands, not just one
Whose icy bits and boulders swing,
Reflecting rays of Sun.

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A billion miles away?
Such treasures will Cassini spy
With Saturn on display!

— *Cherilynn Morrow, 1997*

ENRICHMENT

3

Figure 2

Sensing the "Titan-ic"

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A billion miles away?
What treasures will Cassini spy
With Titan on display?

II. Old Huygens was the first to view
Great Saturn's largest moon.
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