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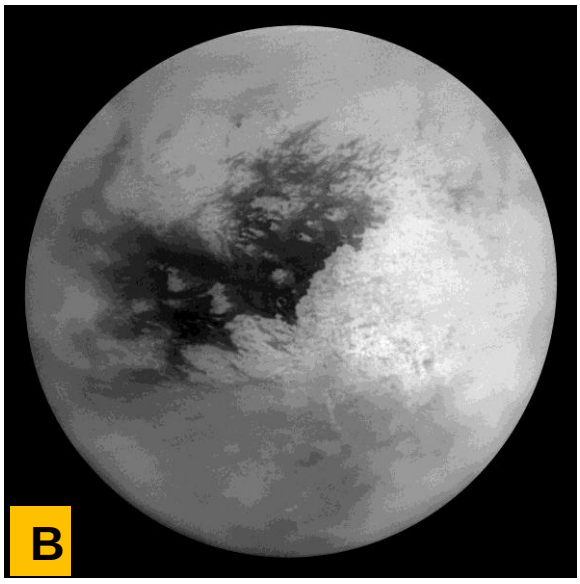
Titan's Temperature

Life on the Edge



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Photography Credits:

A. Picture of a student experimenting with liquid nitrogen.
B. Picture of Titan. NASA
C. An artist's interpretation of Titan's surface. NASA

National Standards Correlation

Life Science Content Standard C

Regulation and Behavior

All organisms must be able to obtain and use resources, grow, reproduce, and maintain stable internal conditions while living in a constantly changing external environment. Regulation of an organism's internal environment involves sensing the internal environment and changing physiological activities to keep conditions within the range required to survive.

Picture of a plant adapting to its environment.

Diversity and Adaptations of Organisms

Millions of species of animals, plants, and microorganisms are alive today. Although different species might look dissimilar, the unity among organisms becomes apparent from an analysis of internal structures, the similarity of their chemical processes, and the evidence of common ancestry. Biological evolution accounts for the diversity of species developed through gradual processes over many generations. Species acquire many of their unique characteristics through biological adaptation, which involves the selection of naturally occurring variations in populations. Biological adaptations include changes in structures, behaviors, or physiology that enhance survival and reproductive success in a particular environment.

Picture of DNA structure

Earth and Space Science Content Standard D

Structure of the Earth System

Water is a solvent. As it passes through the water cycle it dissolves minerals and gases and carries them to the oceans. The atmosphere is a mixture of nitrogen, oxygen, and trace gases that include water vapor. The atmosphere has different properties at different elevations.

Picture of Earth from space

Purpose
To observe the effects of extremely low temperatures on inorganic matter, unicellular organisms, and multicellular organisms.

Key Concepts
- Students will observe the effects of liquid nitrogen on living and non-living matter.
- Properties of matter.
- Possibility of extraterrestrial life.

Common Misconceptions

- Gases cannot be liquefied.
- Boiling occurs at very hot temperatures.
- Liquids cannot exist at low temperatures.

Overview

Astrobiology is the study of whether life might exist elsewhere in the universe. Most other planets and moons have conditions that are harsher than the conditions on Earth. Therefore, to get clues about what kind of life might be able to survive on other planets, astrobiologists study organisms that survive in harsh conditions on Earth. Organisms like this are called extremophiles. Most extremophiles are very simple, unicellular organisms. This is because more complex organisms have a harder time surviving extreme conditions due to their complex body systems.

Titan is Saturn's biggest moon. It was discovered by the Dutch astronomer, Christiaan Huygens on 25 March 1655[3]. It is the second biggest moon in our solar system (the biggest moon is Jupiter's moon, Ganymede) [3]. Titan orbits Saturn at a distance of approximately 1.2 million kilometers (745,000 miles), taking it almost 16 days to complete one orbit! [3]

Scientists have been very interested in Titan because it is the only moon in the solar system that has thick, dense clouds and a planet-like atmosphere[3]. In 1980, NASA sent Voyager I to Titan hoping to solve some of the mysterious features of the moon, but was unsuccessful because it wasn't able to penetrate through the clouds[3]. In 2005, NASA sent the Cassini-Huygen's spacecraft to orbit Saturn and Titan[3]. The spacecraft collected and sent data about Titan's atmospheric composition, and provided a map of its surface (See picture E). [3]

Since Titan is much further away from the sun than Earth, it therefore receives less of the sun's warming radiation. The average surface temperature on Titan is

approximately -178^{o}C or -289^{o}F[1]. At this temperature, most substances that are liquids on Earth are frozen into solids, and most substances that are gases on Earth are condensed into liquids. For example, Titan has rain and lakes made primarily of ethane, a chemical which exists as a gas on Earth. The water on Titan's surface is frozen, but scientists believe there may be liquid water below the surface that could sustain life.

Past NASA spacecraft missions have provided us with important information such as temperature, atmospheric conditions, etc, and we hope that one day it will help us answer the question: "Where did we come from".

To create an environment similar to Titans', you will use liquid nitrogen, which has a temperature of about 77^{o}K (-196^{o}C, -321^{o}F).[2] You will make observations about several substances before and after putting them into the liquid nitrogen.

Prep Time for Teachers- 30 minutes
Class Time- 45 minutes

Objectives

- Students will distinguish between the properties of matter.
- Students will compare and contrast various organic and inorganic materials and their potential existence on Titan.
- Students will learn how to make qualitative observations.

Skills

1. *Predicting* the outcome of an experiment
2. *Controlling* variables
3. *Conducting* an experiment
4. *Collecting, recording,* and *graphing* data
5. *Drawing* conclusions and *communicating* them to others

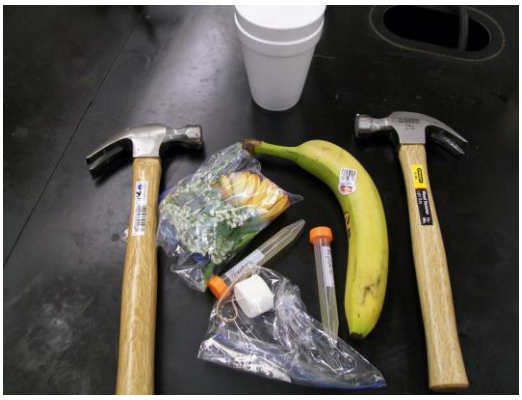
Safety Equipment:

1. Gloves
2. Safety Glasses

Safety:

Liquid nitrogen can burn your skin. You should treat liquid nitrogen like you would treat a very hot liquid: do not touch it, and if any spills, step away from it. It is very important to keep liquid nitrogen out of your eyes, so wear your safety glasses.

Materials



1. Styrofoam cups (1 per student)
2. Liquid nitrogen (approximately 100ml per student)
3. Some or all of the following items: pennies, flowers, lettuce, rubber bands, marshmallows, bananas, balloons (1 of each per student)
4. Sample of *Psychrobacter urativorans* in a test tube (or use *Escherichia.coli*) (1 per student)
5. Tongs (1 per student)
6. Hammer (1 per student)

Part A

Step 1-Put on your safety glasses.
Step 2-Get a sample of liquid nitrogen in a Styrofoam cup.-add pictures next to steps
Step 3-Record the materials you are testing in your Data and Observations page. Is each one living or nonliving?
Step 4-For each material you are testing, record some of its physical properties before putting it into the nitrogen. For example, can you bend the material? What happens if you hit it with a hammer?
Step 5-Use tongs to put your first material into the nitrogen. Leave it in until the bubbling subsides, then take it out with the tongs. Observe its physical properties. Try hitting it with a hammer. (You may have to do this very quickly, before the material warms up.)
Step 6-Repeat Steps 1- 5 for all materials.

Data and Observations
Part A

Fill in the table for the materials you tested.

Material	Living or nonliving?	Observations Before Freezing	Observations After Freezing

Part B (Bacteria and Liquid Nitrogen)
Step 1-Put on your safety glasses.
Step 2-Get a tube of *Psychrobacter urativorans* from your teacher. **State a hypothesis: Will the bacteria survive the liquid nitrogen?**
Step 3-Without opening it, put the tube into your liquid nitrogen using tongs. Leave it in until the bubbling stops.
Step 4-Take out your tube and let it melt.
Step 5-Open the tube and dip a sterile cell spreader into the liquid. Brush the spreader on an agar plate. Be careful not to touch the plate with your fingers, and put the lid on it as soon as possible.
Step 6-Put your name on your plate and keep it at room temperature for several days.
Step 7-Watch for growth.

Data and Observations

Part B

1. Formulate your hypothesis: Will the bacteria survive the liquid nitrogen?

2. Which is a simpler organism, the *Psychrobacter* or the other organisms you froze?

3. How does being composed of one cell make it easier to survive a sudden temperature change?

4. What evidence do you have to suggest that the other organisms didn't survive their freeze? What evidence do you have to suggest that the *Psychrobacter* did survive?

Part C (Liquid Nitrogen + Balloon)
Step1- State your hypotheses about what will happen in Part C of your Data and Observations sheet.

Step 2- Your teacher will demonstrate the effect of liquid nitrogen on a balloon. Watch carefully, then answer the questions on your Data and Observations sheet pertaining to Part C.

Part C

5. Formulate your hypothesis: What will happen to the balloon as liquid nitrogen is poured over it?

6. Formulate your hypothesis: What will happen to the balloon as it warms up afterward?

7. Describe what you saw happen to the balloon. What do you think happens to gases as they are brought to very low temperatures?

References

1. http://en.wikipedia.org/wiki/Titan_(moon)
2. http://www.wolframalpha.com/input/?i=nitrogen&a=*MC.~-_*Word-
3. http://solarsystem.nasa.gov/planets/profile.cfm?Object=Titan