Black Holes: The Ultimate Abyss: Teacher's Guide

Grade Level: 6-8 | **Curriculum Focus:** Astronomy/Space | **Lesson Duration:** Two class periods

Program Description

Nothing psyches up a physicist quite like a black hole, a star that has died and yielded to the gaping maw of gravity. Listen as Stephen Hawking, aided by 3-D animation, explains the concept of space-time and how black holes are formed. Allow yourself to be drawn to the edge of a black hole — the event horizon — and imagine what life would be like inside.

Onscreen Activities

Segment 1, Black Holes, The Ultimate Abyss: Part 1

- Pre-viewing: What do you already know about black holes? Do you think they exist? While you watch the documentary, pay attention to what scientists have actually observed and what is completely theoretical. What methods do the scientific community use to search for black holes?
- Post-viewing: Sir Isaac Newton proposed that the more mass a body has, the more gravity there is in its vicinity. Discuss what mass has to do with black holes. Why is it impossible for our sun to become a black hole?
- Activity: You are an astronomer trying to convince your colleagues that you have discovered a black hole within 30 light-years of our solar system. Describe how you made your discovery and why you know it is a black hole.

Segment 2, Black Holes, The Ultimate Abyss: Part 2

- Pre-viewing: With your classmates, speculate on what might happen if you fell into a black hole. What about a wormhole? As you watch the documentary, keep track of the black hole and wormhole theories that are proposed and the evidence used to support them. How different are they from your ideas?
- Post-viewing: According to the documentary, a wormhole is a theoretical tunnel connecting two black holes. This would provide a means of traveling to different locations in short periods of time. If this is possible, do you think scientists should attempt to create a wormhole? Why or why not?
- Activity: Find out more about the life cycles of stellar mass, supermassive, and mini black holes. Then prepare a presentation for your class that includes their individual characteristics, such as original composition and life span.

Lesson Plan

Student Objectives

Students will understand the following:

- Even though black holes all have characteristics in common, they come in three different sizes.
- Each size black hole has characteristics different from the others.

Materials

- *Black Holes: The Ultimate Abyss* video and VCR, or DVD and DVD player
- Library and Internet reference materials on black holes
- A computer with Internet access

Procedures

1. Review with your students what they have learned about black holes.
2. Make sure they understand that, while black holes have characteristics in common, they differ with regard to size. Explain that black holes come in three sizes: stellar mass black holes, supermassive black holes, and mini-black holes. Explain further that particular characteristics are associated with each size.
3. Divide the class into three teams, and assign each team to research one of the black-hole types discussed above.
4. Tell students that each team will prepare a presentation based on its research, which should include the following:
    - characteristics of the type of black hole
    - lifetime of the type of black hole
    - locations (or suspected locations) of the type of black hole
    - evidence for existence of the type of black hole
5. Tell students to keep track of the sources for their facts so that they or other interested classmates can go back to those sources for further information. Encourage students to include visuals in their reports.
6. After each team has presented its report, invite students to participate in creating on the chalkboard a compare-and-contrast chart showing the similarities and differences among the three types of black holes.

Discussion Questions

1. Discuss how Newton's view of gravity differs from Einstein's view of gravity.

2. Describe how a black hole is formed from the time a massive star begins its collapse.
3. Knowing that density is defined as mass per unit volume, discuss the mathematical characteristics of a singularity (values of mass, density, volume, and radius).
4. Describe the steps involved in determining the mass of a black hole. What do you have to measure or observe in order to estimate the mass?
5. If you were observing a probe entering the event horizon of a black hole, you would see it "hovering for an eternity and destroyed in an instant." Discuss the meaning of this phrase as it applies to conditions near a black hole.
6. Discuss the objective of the Gravity Probe B satellite and its relevance to the study of gravity.

Assessment

Use the following three-point rubric to evaluate students' work during this lesson.

- 3 points: report well-researched, information clearly and logically organized, presentation interesting and lively
- 2 points: report adequately researched, information sufficiently organized, presentation dull
- 1 point: report insufficiently researched, information inadequately organized, presentation poorly prepared

Vocabulary

black hole

Definition: An object with a gravitational field so strong that light cannot escape from it. It is believed to be created in the collapse of a very massive star.

Context: Everybody has heard of black holes; no one has really seen them.

galaxy

Definition: A galaxy that is a powerful source of radio waves.

Context: Mighty jets of energized particles are blasted into space from invisible engines at the hearts of these so-called radio galaxies–further evidence that a black hole is driving the process.

gravity

Definition: A fundamental physical force that is responsible for interactions that occur because of mass. The force of gravity from an object is inversely proportional to the square of the distance away from the object.

Context: Newton reasoned that all matter in the universe has gravity.

mass

Definition: A measure of the amount of material an object contains, which causes it to have weight in a gravitational field.

Context: The more mass a body has, the more gravity.

singularity

Definition: A point or region of infinite mass density at which space and time are infinitely distorted by gravitational forces and which is thought to be the final state of matter in a black hole.

Context: The most terrifying concept of astrophysics lurks at the bottom of a black hole—the singularity—where nothing, not even light, can escape.

space-time

Definition: A system of one temporal (time) and three spatial coordinates by which any physical object or event can be located. Also called the space-time continuum.

Context: Space and time seem to be woven together to form the flexible four-dimensional fabric of the universe: so-called space-time.

supernova

Definition: The explosion of a very large star in which the star may reach a maximum intrinsic luminosity one billion times that of the sun.

Context: When a giant star switches off, it goes out with a bang. While we see the outward explosion as a supernova, this masks the implosion going on inside.

Academic Standards

National Academy of Sciences

The National Science Education Standards provide guidelines for teaching science as well as a coherent vision of what it means to be scientifically literate for students in grades K-12. To view the standards, visit http://books.nap.edu.

This lesson plan addresses the following science standards:

- Earth and Space Science: Origin and evolution of the universe

Mid-continent Research for Education and Learning (McREL)

McREL's Content Knowledge: A Compendium of Standards and Benchmarks for K-12 Education addresses 14 content areas. To view the standards and benchmarks, visit http://www.mcrel.org/.

This lesson plan addresses the following national standards:

- Science—Space Science: Understands essential ideas about the composition and structure of the universe and the Earth's place in it.
- Science—Physical Science: Understands energy types, sources, and conversions, and their relationship to heat and temperature.
- Science—Physical Science: Understands basic concepts about the structure and properties of matter.
- Science—Physical Science: Understands motion and the principles that explain it.