A Curriculum Guide to

George's Secret Key to the Universe

By Lucy & Stephen Hawking

About the Book

When George's pet pig breaks through the fence into the yard next door, George meets his new neighbors—Annie and her scientist father, Eric—and discovers a secret key that opens up a whole new way of looking at the world from outer space! For Eric has the world's most advanced computer, the superintelligent Cosmos, which can whisk George and his friends off to any point in the universe. Suddenly George is on a roller-coaster ride through the vastness of space—past planets, through an asteroid storm, to the very edge of our solar system and beyond. But someone else has plans for Cosmos—plans that will lead Eric and George into terrible danger.

About the Authors

Lucy Hawking, the daughter of Professor Stephen Hawking, is the author of two novels and has written for many British newspapers. She lives in Cambridge with her son.

Stephen Hawking is the Lucasian Professor of Mathematics at the University of Cambridge. He is widely regarded as one of the most brilliant theoretical physicists since Einstein. His adult book *A Brief History of Time* was a huge bestseller (more than twelve million copies sold worldwide) and is now available in more than thirty languages.

Christophe Galfard, PhD, is a former research student of Stephen Hawking and has collaborated on the scientific story line, details, and images within the book.

How to Use This Guide

Use the **pre-reading activities** to build background knowledge and to activate student interest.

Throughout the reading of the book, discuss the meanings of the **vocabulary** words. Students may want to keep a list of these words in a notebook as they read.

During and after reading, use the **discussion questions** to stimulate scientific inquiry and literary analysis. These questions cover various subject areas, from language arts to chemistry, making them perfect prompts for cross-curricular lessons. Most of them relate to a specific page in the book and assume that students have read at least up to that page.

The **activities** encourage reading and writing development and scientific exploration, either through research or through experimentation. Where possible, encourage students to collaborate in order to complete the activities. Remind them that collaboration is central to science. Many scientists work together, building on one another's results so they can advance their knowledge more than any individual could working alone.

The four sections of the book entitled "Cosmos's Picture Files" are addressed separately at the end of this guide. These activities and questions may be useful for struggling or reluctant readers, as well as for visual learners. They are designed to encourage students to find information in the text.

Pre-reading Activities

Before reading the book, have students make a list of questions they have about the planet, the universe, and outer space. Record their questions on the board. As they read, encourage students to check off the questions that the book answers.

Make sure students are familiar with the scientific method (testing a hypothesis through repeated observation and experimentation). You may want to demonstrate the scientific method with a short experiment, such as attracting or repelling various objects with a magnet.

Engage students in a discussion of favorite movies or video games that take place in space. Ask students to identify the elements of such movies or games that are most interesting to them. Tell them that this book is an adventure story that takes place in outer space. Ask students to make predictions as to what this story may be about and what George's "secret key" could be.

Vocabulary

Have students use context clues from the page where the word first appears as well as from a dictionary or other reference sources to determine the meaning of each vocabulary word below.

toxins (p. 4)
additives (p. 4)
phenomena (p.4)
squatters (p. 11)
dense (p.12)
nanosecond (p. 38)
oath (p. 40)
quelled (p. 60)
rebel (p. 60)
random (p. 67)
curdled (p. 67)
parched (p. 72)
portal (p. 83)
rubble (p. 95)
droughts (p. 144)
consuming (p. 144)

Discussion Questions

1. George's family lives without a lot of modern inventions and appliances (p. 4). Why do they choose to live this way? How does George feel about this way of life? What inventions or appliances do you most rely on? What could you live without?
2. George's mother tells him he asks too many questions (p. 10). What are you curious about? Could you find the answers through research, through scientific experimentation, or another way? Write down three questions you've always wondered about. Then write down what you think would be the best way to find the answers.
3. Who is Annie and how is she different from George (p.18)?
4. How does Eric introduce George to science (p. 26)? Do you agree with Eric's definition of science? Why or why not?
5. Eric discusses physics (p. 26). What are some of the other types of natural science? What questions do they try to answer?
6. Why isn't Eric upset at the damage the pig has caused (p. 31)? What does his reaction suggest about what scientists can learn from unexpected events? What would happen if every science experiment worked as planned?
7. Who is Cosmos (p. 37)? Describe Cosmos's "personality." Would you like to have a computer like Cosmos? Why or why not?
8. Cosmos shows George a view of billions of stars in the universe (p.45). How are stars made?
9. What is an atom (p. 47)? Why isn't it an elementary particle? How do you think a particle can carry light?
10. What is matter (pp. 50–51)? What is the structure of atoms?
11. Do you agree with Reeper that life is not fair (p. 63)? Why or why not?
12. What is the average temperature where you live (p. 79)?
    How do you convert degrees Fahrenheit to degrees Celsius?
13. Read the following passage:

    > "We're not doing nothing," squealed Ringo.
    > "I think you mean, 'We are not doing *anything,*'" corrected Dr. Reeper in a teacherly voice (p. 92).

    Why does Reeper correct Ringo? Give another example of a double negative.
14. Why is outer space cold (p. 94)?
15. Why aren't mass and weight the same thing (p. 99)?
16. What does Einstein's equation $E = mc^2$ mean (p. 99)? What does each letter stand for?
17. When will Halley's Comet be visible from Earth again (p. 104)? What other comets will be visible from Earth before 2100? Why do some comets *not* orbit the Sun?
18. Jupiter takes 11.86 Earth-years to circle around the Sun (p. 122). Why does the book give orbits in Earth-years? How long is a year on Jupiter? (Hint: Multiply 365 × 11.86. Remember that the answer will be in Earth-days, because days are also determined by planetary motion.)
19. Reeper tells the rebel boys they must "learn to distinguish between science fiction and science fact" (p. 166). What is science fiction? How is it different from other types of

fiction, like historical fiction? Have you read any other books that could be classified as science fiction? How were they similar or different from this book?

20. What are exoplanets (pp. 166–167)? Why are they so difficult to detect? Do you think scientists will ever detect any Earth-size exoplanets? Why or why not?
21. George's dad goes on protest marches to show his opposition to global warming. What other social movements have relied on protest marches? Are marches effective? Why or why not?
22. Why might George's space rock crumble into dust in Earth's atmosphere? (p. 172)
23. Why can't Cosmos go to a place Eric has not discovered (p. 215)? What can't computers do?
24. Summarize Eric's research about black holes (pp. 230–239). Why do time and space slow down near a black hole? Why do objects appear dimmer?
25. How does Eric escape the black hole?
26. Now that you have finished reading the book, identify the protagonist (the main character) and antagonist (the person the protagonist struggles against). What are some of the conflicts, or struggles, in this story? What event resolves, or ends, most of these conflicts?

Activities

Research

The following activities involve student research. Direct students to appropriate Internet and library resources to complete the activities.

1. Have students observe the night sky from where they live (p. 8). (If safety is a concern, arrange a field trip to the school playground.) Have students create a sky map, in which they diagram and label the constellations they can see.
   Follow-up: Constellations seem to move across the sky, just as the Sun does. Why might that be? One star, the North Star, is said to be "fixed"—its position in the night sky doesn't change. Why doesn't its position change? Does it appear to be in the same part of the sky from every place on Earth? Explain.
2. Imagine that scientists have announced the discovery of a new object in the solar system. It has a diameter of about 4,500 miles, and it is almost round. It orbits the sun, and its orbit contains many rocks and asteroids. Is this object a planet or a dwarf planet? Why? (Hint: See p. 87.)
3. How do scientists determine the surface area of planets? Have students find the formula for the surface area of spheres. What would be the surface area of a planet with an equatorial diameter of 15,640 miles?
4. Have students research discoveries that have come about from unexpected events or chance observations, such as the discovery of penicillin or Galileo's discovery of pendulum motion.
5. Have students find and read news stories from August 2006 about Pluto (p. 87). Encourage students to write fictional news stories of their own about a scientific finding. Compile students' stories into a fictional newspaper. Have students create illustrations or stage photographs to accompany their stories. Distribute copies of the completed student paper to other members of the school community.

6. Explore the idea that “Mass and energy curve space, creating gravity” (p. 99). What does this mean? How can mass curve space?
7. Have students look at the discussion of temperature on p. 79. Point out that one of the earliest thermometers was invented by Galileo. Galileo’s thermometer worked on the principle that water expands when it gets hotter. How could that principle have helped him design a thermometer?
   Before thermometers, scientists could only talk about temperature in relative terms−for example, “This cocoa is hotter than that rock.” Why might it be more useful for scientists to talk about temperature in terms of degrees? Why do we have several different temperature scales (Fahrenheit, Celsius, Kelvin)?
8. George can’t talk to Annie when the antenna on her helmet is broken (p. 123). Why? How do antennas work? Find out!
9. Have students do research on global warming (p. 145). What causes it? What might happen because of climate change? Ask students to find three different scientific scenarios for the future.
10. Cosmos used to be “so big he took up a whole basement” (p. 278). Have students research the history of computers and present their research in the form of a presentation. Presentations should make use of visuals and should answer the following question: What advances have made it possible for today’s computers to be so small compared to the computers of the past?

<u>Experiment</u>

1. How do comparisons help writers describe places and things to readers? Select an object in the room (a book, a piece of classroom equipment), and have students write two descriptions of it, both assuming that the audience has never seen such an object before. The first description must be literal: students must describe the object as accurately as possible. They may not compare it to anything else. In the second description, they may use comparisons (*it’s the color of ___; it’s about the size of __; it has a nozzle like ___*). How do comparisons help them get the point across? In science, what might be a danger of using comparisons to describe something?
2. Have students duplicate Eric’s demonstration with the plastic ruler and static electricity (p. 23). How does it work? What is static electricity?
3. Observe the moon for a month. Chart its phases, as well as when and where it rises and sets in the sky. Try to observe it in relation to some stationary landmark, such as a tall building or a steeple. How do you think early scientists figured out how the moon moved?
4. Eric shouts “Eureka!” when he finds the note about the new planet (p. 197). *Eureka* comes from a Greek word meaning “I have found it!” Supposedly, the ancient mathematician Archimedes exclaimed “Eureka!” when he figured out how to measure a solid’s volume by water displacement. Provide students with several different irregular solids (for example, a key, an apple, a small toy, a fork). Fill a large, clear graduated container, such as a glass measuring cup, with water. Discuss the formula for calculating volume (V = length × width × height). Ask: How can you find the volume of these objects, when their length and width and height are so irregular? Have students find the volume of each solid by measuring the amount of water it displaces.

Extend

1. Eric says that Galileo discovered that the Earth goes around the Sun (p. 32). What did people believe before Galileo? Have students research medieval, Galilean, Copernican, and modern models of the solar system. Have them draw each model on a large sheet of paper. Display their drawings side by side to compare and contrast. Ask: Do you think today's model of the solar system is accurate? Why or why not?
2. Have students read the oath of the scientist (pp. 40–41) out loud. Discuss why such an oath might be necessary. Ask students to create their own oaths, either for scientific inquiry or for another pursuit they value highly. Encourage them to write their oaths in cursive or to use calligraphy pens.
3. George tells his father he could use computers and the Internet to organize his ecological work (p. 171). Have students think of a social or ecological cause they would like to help. Then have them list three ways they could use computers to raise awareness or make their activism more effective. Invite students to share their ideas with one another or the school community.
4. This book deals mainly with modern physics, the branch of inquiry that began with Einstein. Advanced students may be interested in exploring classical or Newtonian physics. Encourage them to search for information about inertia and motion using library resources.
5. Many planets and constellations have names that come from Greek and Roman mythology. Have students pick a planet or constellation and write and illustrate a short version of the related myth. Compile students' myths into a class anthology, pairing each myth with a drawing or photo of the related planet or constellation.

Cosmos's Picture Files

Collection One (between pages 58 and 59)

1. Why can't the far side of the Moon ever be seen from Earth?
2. What is Earthshine? Do all planets shine?
3. Look at the "pillars of creation." What is happening here?
4. What is infrared light? What is ultraviolet light?

Collection Two (between pages 122 and 123)

1. If it takes about 650 years for light from the Helix Nebula to reach Earth, what is the distance between Earth and the Helix Nebula in miles? (Hint: See the definition of *light-years* on p. 34.)
2. Imagine a comet's surface. Does the photo of Tempel 1 resemble what you pictured?
3. Why might the photo of Titan resemble photos of Earth?
4. What does "geologically active" mean?
5. Why do you think the captions talk about "water ice," not just "ice"? What other kinds of ice are there?

Collection Three

1. Compare images of the Great Red Spot with satellite photos of large hurricanes, such as Katrina. How do the planets' rotations shape weather patterns?
2. Have students compare the photo of sunset on Mars with photos of sunset on Earth. Why might they seem so similar?
3. At what size is a planet or moon "too small to be round"? What forces shape planets?

Collection Four

1. What are the main shapes galaxies can have?
2. Why might there be a black hole at the center of most galaxies?
3. Look at the map of the solar system. Note that the distances between the planets and the Sun are not to scale. How big would the book have to be to include a scale map of the distances? Have students first figure out the scale of this map, using the planet fact charts in the text. Then have students go through the book to find the outermost planet's distance from the Sun. On the diagram's scale, what would that distance be?

Many of the questions and activities in this guide correlate to the NCTE, NSTA, and NSES standards.

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