A Black Hole Is NOT a Hole ACTIVITY KIT

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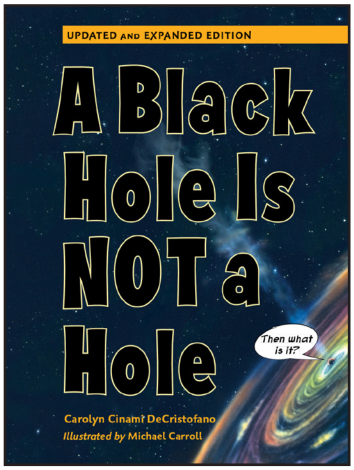
★ "Stargazers will be entranced . . . . An excellent resource."
—*Kirkus Reviews*, starred review

★ "Writ[ten] with rare verve . . . this book will snatch readers from their orbits and fling them into a lasting fascination. . . . "
—*Booklist*, starred review

★ "Informative, fun, and so beautiful that even general readers will be drawn into it."
—*School Library Journal*, starred review

★ "[P]erfectly attuned to the comprehension levels of the target audience."
—*Horn Book Magazine*, starred review



Carolyn Cinami DeCristofano
Illustrated by Michael Carroll
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About the Book

What is a black hole? Where do they come from? How were they discovered? Can we visit one? Carolyn Cinami DeCristofano takes readers on a ride through the galaxies (ours and others), answering these questions and many more about the astronomical phenomenon known as a black hole. An excellent introduction to an extremely complex scientific concept for young readers interested in the universe.

About the Author

Carolyn Cinami DeCristofano has been named a Creative Teaching Partner by the Massachusetts Cultural Council. She has developed science programs with NASA and the Harvard-Smithsonian Center for Astrophysics. Carolyn is also the author of *Leonardo's ABC*. She lives in Plympton, Massachusetts.

About the Illustrator

Michael W. Carroll is an artist and science journalist. His art has appeared in several hundred magazines throughout the world, including *Time, Smithsonian, National Geographic*, and *Astronomy*. His articles have appeared in *Popular Science, Astronomy, Sky & Telescope, Artists*, and *Earth* magazines. He also wrote and illustrated a series of children's books, which includes *Spinning Worlds, Volcanoes & Earthquakes*, and more. Mike lives with his family at the foot of the Rockies in Littleton, Colorado.

Pre-Reading Knowledge Check

What do you already know? Take a moment before reading to define some essential concepts together as a class.

Celestial Bodies

1. What is outer space?
2. What is a star? How are stars formed?
3. What is a planet? How are planets formed?
4. What is a supernova?

Physics

1. What is light? What is dark?
2. What is gravity? How does it work?
3. What relationships exist between speed and time? What is a light-year?
4. What does it mean to orbit something? How does this phenomenon relate to speed and gravity?

Giants of Science

1. Who is Sir Isaac Newton? What did he contribute to our understanding of gravity?
2. Who is Albert Einstein? What did he contribute to our understanding of space and time?
3. Can you think of any other scientists by name who advanced our understanding of physics and/or astronomy?

A Black Hole Is NOT a Hole Activity Kit

Discussion Guide

Use these questions to kick off classroom discussion, guide pre-thinking and post-reading responses, or inspire a writing or drawing assignment!

Discussion & Writing

1. In this book a black hole is compared to a hungry beast and to a whirlpool. Why use a metaphor instead of simply explaining the properties of a black hole? How are these metaphors suited to describe this phenomenon? Can you think of other metaphors that fit?
2. What tools and phenomena do scientists use to detect black holes? Why is this process so difficult?
3. This book is full of artists' renderings of outer space. Why not use photography? How do these images enhance your understanding of celestial bodies? What did the artists base their work on?
4. Why did scientists want to photograph a black hole? What were some of the technical challenges they faced?
5. What are the differences between a "spinner," a "lumpy," and a "smoothie"?
6. Take a close look at the author's note and resources list. After looking at how she sourced her information, do you think this book is a reliable resource? What are the benefits of reading this book as opposed to doing all the research Carolyn Cinami DeCristofano describes?
7. What does the author mean when she uses the word "pull"? What examples does she use? Can you think of any other examples?
8. Why is a black hole black? Why can't you see light coming from inside of a black hole?
9. Do you think our own Sun could become a black hole?
10. If you cannot see a black hole, how do you know it's there? Visit the Event Horizon Telescope on page 54 to see a telescopic image of a black hole. List the evidence you would need to declare a black hole's existence.
11. The author includes a joke in the book: "If it looks like a duck, and quacks like a duck, then we can safely state it is likely to have its identity as a duck confirmed at some point in the future, pending additional evidence." It's funny, but is it true? Why do you think science moves so slowly?
12. After reading, take a look at the list of "Top 7 Questions You May Have Had About Black Holes" on the back cover of this book. Can you answer these questions? Where in the book did you find your answers?

A Black Hole Is NOT a Hole Activity Kit

Activities

Get hands-on with these practical activities.

Art Connections

1. Take a look at the diagram of a black hole on page 16. How would you translate this flat diagram to a three-dimensional model? Take a look at other illustrations and diagrams in this book and render your model using whatever materials you think necessary—clay, fabric, cardboard or construction paper, wire, tinfoil, etc.

2. In Chapter 3 we learn how a black hole begins. Try drawing a storyboard of the beginning, middle, and end of a black hole's life.

Spatial Connections

1. How big is space? Use a solar-system modeling exercise from NASA or *National Geographic* to visualize the distances involved in our solar system.

2. Try this gravity experiment called **Racing Gravity**
    - Toss a ball up in the air at three different speeds—slow, medium, and fast. What similarities and differences did you notice across the tosses?
    - How is this experiment like the fish, the boat, and the whirlpool (page 8)?
    - The faster the object moves away from the Earth, the farther it can go before Earth's gravity pulls it back. If a launcher tossed the ball much faster, it would escape the Earth's gravity zone. Only black holes have utterly irresistible gravity zones.

Math Connections

3. Try this speed experiment called **Race to the Moon**
    - Run 20 feet. How long did it take you?
    - Run 40 feet. Did it take twice the time?
    - Calculate the time it would take you to run 1,250,000,000 feet, which is one and one-fourth billion feet. That's the distance from Earth to the Moon.
    - How long would it take you to get to the nearest black hole?

A Black Hole Is NOT a Hole Activity Kit

Mystery Can

Learn to think like a scientist with this immersive project!

You will need:

- Easel sheets or whiteboard/chalkboard
- 6–10 identical metal Mystery Cans (paint cans, coffee cans, etc. all work well)
- 2–3 everyday objects to put in each container (pick at least one per can that will make noise when container is shaken)
  ex: washers, nuts, coins, marbles, dice, batteries, spools, pencils, chains, paperclips, buttons, pom-poms, rubber snakes, erasers, felt, craft foam, crumpled-up paper, wrapped hard candy
- Duct tape for sealing container lids
- Optional: spare empty cans & filler objects so students can test their hypotheses; tools for students to test cans, such as a tank of water (buoyancy), scales (weight), ramp (motion), magnets, etc.

To prepare:

If possible, enlist someone else to do steps 2 and 3 while you are not around so you do not know the cans' contents.

1. If you are implementing this activity in conjunction with *A Black Hole Is NOT a Hole*, decide whether you want students to complete the book before the lesson or use the lesson to frame their reading of the book.
2. Fill each can with identical item sets, 2–3 items per can. For older students (grades 4 and up), consider making two sets of cans.
3. Seal each container well.
4. Before students arrive, place one can on a table or stool so that every student will be able to see it.

Procedure:

1. **Begin with a relatable question:** Have you ever received a gift and tried to guess what's inside? How is science like trying to guess what's inside a package?
2. **Connect to black holes (or other science topics):** Black holes are a great mystery. Scientists weren't even sure they existed, but by making observations and connecting to other information, they were able to find them. But scientists didn't just point telescopes to the sky and see them. They inferred (figured out) the existence of black holes by the effects they have on their surroundings—just as you can sometimes infer (figure out) the contents of a gift by shape of the package, the sound it makes when you shake it, or by feeling through the wrapping paper. Science is really about exploring things that make us curious and finding out more about the unknown.
3. **Introduce the Mystery Can:** Call students' attention to the Mystery Can that is in front of the classroom without moving it.

   Tell students that you want them to get a feeling for this exploration of the unknown. They will use the same skills as scientists to try to figure out everything they can about the contents of the can. The challenge is not to only answer "What's inside?" but also to describe the contents. In fact, they may not be able to say exactly what is inside, but they will collect lots of information.

Procedure (cont'd):

3. **(cont'd)** Students may begin to start guessing right away. Let them enjoy this a little, but also chime in and point out that these guesses are based on some observations they are making and knowledge they already have. If students don't start calling out, ask them:

   What do we already know about what's inside the can?

   You might get stumped silence. You can follow up with questions to point out the obvious, such as: "Do you think there's a car inside? A text book? Why (not)?" On the other hand, students might readily realize that the contents must be small, or make other conjectures, which you can field. Keep asking students to justify their statements. As they do so, note what's an observed fact, and what's an inference (something they've figured out by using the fact/observation).

4. **Lead students to think about how they could collect new observations about what's inside the can.**

   Ask: *How could we find out more about what's inside the can?*

   One important, obvious response is opening it and looking inside. If students don't bring this up, mention it. Tell them that often, science can be straightforward—like when students dissect a flower, watch fish in a fish tank, etc. However, sometimes science is not that straightforward, so they will NOT be able to open the cans and look inside. Ask them to suggest other things they could do, and encourage them to state what these actions would reveal, or how they would help students make more observations.

   Give the can one little shake, enough to tantalize students. Ask them to share their observations. They may start guessing; gently redirect their attention to describing and noting their observations. Point out that their guesses about what's inside are inferences based on their observations.

5. **Allow students to explore the contents of cans.**

   Invite students to explore cans of their own and collect as many observations as they can in a few minutes.

   Establish rules: This is exciting and noisy! Tell students how you will call their attention, and be clear on the fact that when you do so, you expect them to place the can on a surface, with no one touching it during the discussion. Also set the expectation that students will share the cans with each other in their small teams. You can allow/encourage cross-team sharing and comparing as well.

   Distribute cans to small groups of students. Allow them to try whatever (safe, reasonable) manipulations of the can they think of. Circulate among the groups asking them to share their observations. Ask for detail and for their thoughts/inferences, continuing to emphasize the difference between observations and inferences.

6. **After several minutes, call the class's attention and discuss their findings.**

   During the discussion, allow one student at a time to demonstrate with the can, if that seems appropriate.

Procedure (cont'd):

6. **(cont'd)** For example, if a student says, "It made a clinky noise," you might ask the student to re-create that noise so the rest of the class can hear it.

   As you collect observations, ask other groups to comment on whether they made the same observation/heard or felt the same thing. As needed, you can invite student teams to pick up their cans and try whatever a speaker demonstrates.

   Point out observations that are the same and those that don't seem to be universal. Ask students why they think that might be. (Possible answers: The test was not exactly the same. (This is an opportunity to remind students about "fair tests"/controlled experiments.) The contents may not be the same. Students observe differently.)

   Treat the possibility of the contents of the cans being different across (at least some) cans as a major discovery. Encourage students to probe that possibility. (You can have teams with potentially different cans demonstrate some shaking/rolling/movements/other tests for comparison.)

   Consider scribing student observations on a T-chart.

   Sum up the observations before moving on to Step 7.

7. **Give students a few minutes to talk to each other about what they think they can confidently say about the contents of the cans.**

   Encourage them to both describe the contents ("There are multiple objects, some made of metal") and try to identify the contents ("I think they are coins"). Group members do not have to agree but should help each other think through their responses .

8. **Ask students to share their ideas. Focus on the descriptions and the conclusions.**

   Ask students to explain why they think what they think. Which observations are they drawing from? Point out that ideally, a good inference about the contents of the can is that it should account for all observations. Which observations might be unaccounted for by any inference?

   Note that in real-world science, some leading ideas don't account for, or explain, all of the observations. The strongest, and most broadly accepted, ideas do account for all or the vast majority of observations. They also allow for predictions that can be tested. The predictions should allow the idea to be eliminated or strengthened.

9. **Make a connection to real-world science.**

   Refer back to *A Black Hole is NOT a Hole* (or other science content) and ask students to identify any observations and inferences that helped to build the idea of black holes and identify specific black holes.

   Also focus on any science experiences that the class has engaged in, connecting their science to real-world science. They both (should) focus on the discovery of the unknown.

Mystery Can

Learn to think like a scientist with this immersive project!

Procedure (cont'd):

9. (cont'd) Now would be a perfect time to discuss question 11 in the discussion guide (page 3 of this document), referencing the joke that begins "If it looks like a duck and acts like a duck . . ."

10. Collect the cans.

Students may groan—why can't they open the cans now? Also they may ask you if they are right about the contents of the can.

If you have elected not to know what's inside the cans, consider NOT opening the cans. Tell students that to be fair, you also made sure you do not know the contents, and that this is the way science is sometimes. There's nobody who will tell scientists if they are correct or not with their ideas. Only the world/universe can tell them, by revealing more information that scientists can observe. (Scientists can think of new ways to get that information, like, say, modeling—taking an empty can and filling it with known objects representing what they think might be inside the mystery can, and comparing observations.)

Or depending on the age of students, you can try opening the cans. For educational value, compare observations to the contents: How does knowing what's inside help explain the observations?

Optional Extensions:

These may be offered as formal lessons or at an activity table.

If you have not opened the can(s):

- Offer students the opportunity to model their inferences and ideas about what's inside the can, using spare cans and an array of filler ojects. You might want to encourage this to be a more systematic process by asking students to track their models, experiments, results, and what they will try next (and why).
- Offer students the opportunity to try experimenting with new approaches, such as using magnets on the outside of the can, rolling cans down a ramp, testing for buoyancy, etc., to help refine their ideas about the mystery can's contents.

If you have opened the can(s):

- Encourage students to continue to practice their skills by creating new mystery cans to share with each other.
- Consider using these new cans over time, but telling students that there will be one master mystery can that they won't open. Introduce that can after a few weeks and conduct the exploration as in the main activity.