

The Dinosaur Detectives: How Walter and Luis Alvarez Solved the Mystery of Dinosaur Extinction

written by Cindy Jenson-Elliott

illustrated by Theo Nicole Lorenz

About the Book

Genre: Nonfiction

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Reading Level: Grades 6–8

Interest Level: Grades 6–12

Guided Reading Level: X, 6th Grade

Accelerated Reader® Level/Points:
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Lexile™ Measure: N/A

*Reading level based on the ATOS Readability Formula

Themes: Dreams & Aspirations, Earth Science, Education, Geology, Graphic Nonfiction, International Cooperation, Middle Grade, Nature / Science, Nonfiction, Occupations, Photographic Illustrations, Scientific Modeling, STEM / STEAM, United States History, World History

Resources on the web:

leeandlow.com/books/the-doomsday-detectives

SYNOPSIS

Cretaceous earth was known as the age of dinosaurs. But really, it was the age of LIFE—scaled and feathered, furry and leathered, budding, blooming, roaring, zooming, buzzing, glorious LIFE—until...DOOMSDAY.

For 66 million years, the mystery of what happened to the dinosaurs lay hidden under layers of sand and silt, until scientists began to piece together the puzzle of what happened on the last day of the ancient world.

Follow the real-life adventures of father-son scientists Luis and Walter Alvarez—along with an army of science detectives—as they unlock the world's most intriguing mystery.

Learn how the smallest particles in the universe helped explain what happened to the largest animals that ever walked the planet. Track the timelines of discoveries from the 1600s to the present day in physics, paleontology, astronomy, and geology that had to happen before humans could understand how and why 75 percent of species suddenly went extinct.

This is the story of how scientists add to the sum total of human knowledge, one question at a time, and help us understand our beautiful, tragic, and magnificent world.

All guided reading level placements may vary and are subject to revision. Teachers may adjust the assigned levels in accordance with their own evaluations.

BACKGROUND

Background and Next Generation Science Standards

Scientific understanding builds, one idea at a time, over hundreds of years. Before scientists could understand what caused the Cretaceous extinction, they needed to understand how Earth was formed and how and why it has changed over its 4.5 billion year history. Similarly, for students to understand the Alvarez Hypothesis, they need to have a grasp of some basic concepts in Earth Science, such as how Earth was formed, what tools scientists developed to measure its age, and how it changes over time. *The Doomsday Detectives* guides students through not only the geologic history of Earth, but the history of scientific discovery. As they read, students develop an understanding of NGSS Science Practices, Middle School Disciplinary Core Ideas related to Earth Science, Physical Science, and Life Science, and a variety of Cross-cutting Concepts that will help them complete the MS-ES Performance Tasks.

Next Generation Science Standards included in *The Doomsday Detectives*:

Disciplinary Core Ideas:

MS-ESS1-4

MS-ESS2-1,2,3,4

MS-ESS3-1

Cross Cutting Concepts: Patterns; Scale, Proportion and Quantity; Systems and System Models; Cause and Effect; Stability and Change.

Science Practices from *The Doomsday Detectives*:

Scientists use these practices in any order to solve problems and answer questions:

Science Practices:

- **Make Observations:** Scientists use their five senses, sometimes enhanced by tools, to examine the world.
- **Ask Questions:** Scientists wonder about something, and then put together a specific question to express their wonderings.
- **Modeling:** Scientists make and use models to explain how things work. Models change as their understanding changes.
- **Collaborate:** Scientists work together to answer questions and solve problems.
- **Gather Data:** Scientists gather as much information related to the question as they can. The information can be qualitative (descriptive) or quantitative (using numbers and measurements).
- **Hypothesize:** Scientists create an idea, called a hypothesis, that can be tested to explain as much of the existing data as possible.
- **Investigate, Challenge, and Test:** Scientists find ways to test hypotheses using quantitative data.
- **Analyze:** Scientists examine what all the data means, especially the new data that results from testing their hypotheses.
- **Argue Using Evidence:** Scientists present ideas and share evidence to argue why their ideas are correct. Other scientists challenge these arguments.

- Communicate: Scientists share their data and ideas with the world.

Lesson Idea for Pre-teaching Science Practices:

https://docs.google.com/document/d/1Hxr4-2q9G4pkuOrqMmwf0DDM3QY2a0d_ELafqrdqbVQ/edit?usp=sharing

Key Vocabulary**Glossary and Index**

Bolded words allow students to look up key vocabulary in the glossary in the back of the book. Students can also use the Index to look up specific topics featured in *The Doomsday Detectives*.

Background Research for *The Doomsday Detectives*

Walter Alvarez's 1997 book, *T-Rex and the Crater of Doom*, and Luis Alvarez's 1987 memoir, *Alvarez: Adventures of a Physicist*, helped the author, Cindy Jenson-Elliott, create a narrative throughline based on the Alvarez's lives and work. Books in science and history, interviews with scientists and other individuals involved in the historical period and scientific discoveries, and scientific papers detailing discoveries helped her write expository and graphic nonfiction related to these discoveries.

The remainder of the 131 sources used in writing this book are available in the Source Notes of *The Doomsday Detectives*, including books and articles on the following topics:

- Early Dinosaur Discoveries and Ideas of Extinction
- Geologic Laws and Processes; Geologic Time
- Uniformitarianism and Catastrophism
- Cosmic Rays and Ionizing Radiation
- Tsunamis, Sedimentology, and Stokes's Law
- Astrogeology and evidence from Outer Space
- Geologic Evidence of an Asteroid Impact
- Alternative Hypotheses, Deccan Volcanism, and Controversies
- Current Research on the Cretaceous Extinction
- Diversity in US Geosciences

Teaching Resources on Earth Science and the Cretaceous Extinction

The National Museum of Natural History has resources dedicated to teaching about the Cretaceous Extinction, "Mass Extinction of Large Dinosaurs and More" (<https://naturalhistory.si.edu/education/teaching-resources/paleontology/mass-extinction-large-dinosaurs-and-more>). These pages include videos, lesson plans, posters, literacy resources, and Next Generation Science Standards alignment.

The American Museum of Natural History's "Dinosaurs: Activities and Lesson Plans" includes resources, lesson plans, educator materials, articles, and tools to inform teaching about dinosaurs and dinosaur extinction (<https://www.amnh.org/learn-teach/curriculum-collections/dinosaurs-activities-and-lesson-plans>). The National History Museum's "The Cretaceous Period: What Was Earth like before dinosaurs

went extinct" provides information on the Cretaceous Period and a section on how it ended and what happened to the dinosaurs (<https://www.nhm.ac.uk/discover/the-cretaceous-period.html>). "How an asteroid ended the age of the dinosaurs" (<https://www.nhm.ac.uk/discover/how-an-asteroid-caused-extinction-of-dinosaurs.html>) explains what happened the day the dinosaurs died and cites Luis Walter Alvarez and Walter Alavarez and their contributions to the field.

PBS's "What Killed the Dinosaurs?" also includes activities and resources dedicated to teaching about Dinosaur extinction (<https://www.pbs.org/wgbh/evolution/educators/lessons/lesson1/act2.html>). The National Center for Science Education's "Road to Extinction" is a lesson set that explores extinction, evolution, and biodiversity (https://ncse.ngo/sites/default/files/EVO_LessonSet5-TheRoadToExtinction_2.pdf).

The University of Texas has a lesson plan with resources and links about teaching about the K-Pg Boundary (Formerly known as the K-T Boundary.) (https://www.esi.utexas.edu/files/054-Lesson-Plan-What-is-a-K_T-Boundary_.pdf) Note: the K-T boundary is now referred to as the K-Pg boundary.

Carleton College's "All Things Cretaceous: A Digital Resource Collection for Teaching and Learning" has resources, lesson plans, and guiding questions for students (https://serc.carleton.edu/research_education/cretaceous/keyquestions.html).

The United States Geological Survey (USGS) "When did dinosaurs become extinct?" has sections dedicated to learning more about dinosaur extinction (<https://www.usgs.gov/faqs/when-did-dinosaurs-become-extinct>).

Expository Nonfiction Text Features in *The Doomsday Detectives*

To best engage with students reading *The Doomsday Detectives*, utilize the following text features integrated throughout the book:

- Callout boxes in grey about specific scientific terms, events, and topics
- Timelines
- Quotes from different scientists
- Boldface type for names of people, organizations, events, certain terms, and questions for reflection;
- Photos and maps with captions.

Graphic Nonfiction Elements

Use *The Doomsday Detectives* to introduce students to the main elements of graphic nonfiction.

Define these elements for students and give them time to discover each in the book:

- Panel: A distinct segment of a comic, with a combination of image and text.
- Frame: lines and borders that contain the panels.
- Gutter: space between framed panels.
- Speech balloon: words come from a specific character's mouth to showing dialogue and words spoken out loud.

- Thought bubble: words show unspoken thoughts from a specific character.
- Caption: boxes containing a variety of text elements and narration, including scene-setting, description, and explanations.
- Special-effects lettering: highlight drama, exaggeration and sound, reinforcing the impact of words such as “bang” or “wow.”
- Foreground: The art can be perceived as closest to the viewer within the panel.
- Background: Provides additional, subtextual information for the reader.

Teaching Students to Read and Draw Graphic Nonfiction

Use the following slides to teach students to recognize and use the six comic shots, as well as different points of view and graphic elements to tell stories and explain science concepts. You can have students practice using comics to retell parts of the story, to model scientific concepts to check for their understanding, or just to enjoy exploring the comic narrative process.

https://docs.google.com/presentation/d/1F4dgsBQ_avf1atDzMXikhuWrANRL2WrWHHpvkhwqelU/edit?usp=sharing

The Six Comic Shots

- **Establishing Shots:** Shots that establish setting, usually on every page;
 - **Extreme Long Shot:** Used to show setting from far away without characters;
 - **Close Up:** Used to show setting with characters visible from a distance.
- **Full Shot:** Used to show the full body of a character moving from place to place within a setting;
- **Mid Shot:** Upper body; Used to show a character doing something with their hands in one place, and/or dialogue between two characters.
- **Close Up:** Used to focus in on something important such as a character's facial expressions, or an important object;
- **Extreme Close Up:** Used to show something of extreme importance to convey drama.

Points of View

- **Bird's Eye:** What a bird would see, looking down on a scene;
- **Drone Lens:** What a drone would see, high up and looking down;
- **Worms Eye:** What a worm would see, looking up and closing in on a subject;
- **Satellite View:** View from high above the Earth, looking down.

More Resources for Teaching with Graphics and Comics

- Reading Rockets has several articles about teaching with and about graphic novels (<https://www.readingrockets.org/topics/childrens-books/articles/graphic-novels-young-kids>) (<https://www.readingrockets.org/topics/childrens-books/articles/graphic-novels-kids-classroom-ideas-booklists-and-more>).

- NCTE: <https://www.readwritethink.org/classroom-resources/lesson-plans/comic-book-show-tell>

BEFORE READING

A Guide to Scientific Practices from *The Doomsday Detectives*

Science practices are key activities scientists perform over and over in any order to answer questions and solve scientific problems. Understanding and practicing these practices through the lesson below before they read will help students understand the book better.

Pre-Reading Scientific Practices Activity

Introduce the scientific practices below and their definitions. Then give students an opportunity to explore and experience the scientific practices with ordinary natural phenomena in your schoolyard using the attached worksheet:

https://docs.google.com/document/d/1Hxr4-2q9G4pkuOrqMmwf0DDM3QY2a0d_ELafqrdqbVQ/edit?usp=sharing

1. Observe and Collaborate in discussing one of the following phenomena as a group or in pairs of students:
 - Weeds in the school yard;
 - Animal holes in the school grounds;
 - Animals on the school grounds – birds, squirrels, insects or spiders;
 - Bird behaviors;
 - Weather conditions;
2. Ask questions about the phenomena: What is it? What caused it? How did it get there? Where did it come from? What is it related to? What does it do? How does it survive? Why does it behave in this way?
3. Model an explanation of the phenomena by drawing what you think is going on.
4. Hypothesize: Write a testable if-then statement to explain what you see.
5. Investigate, Challenge and Test, and Gather data: observe and record information about your phenomena. Record your data by writing or drawing.
6. Analyze: Look at your data. Was your hypothesis proved false? If not, it may be true.

Prereading Focus Questions

(Reading Standards, Craft & Structure, Strand 5 and Integration of Knowledge & Ideas, Strand 7)

(Speaking & Listening Standards, Comprehension & Collaboration, Strands 1 and 2)

Before introducing this book to students, you may wish to develop background knowledge and promote anticipation by posing questions such as the following:

- What do you know about dinosaur extinction? How do you think dinosaurs became extinct? How did you learn about dinosaur extinction?
- What do you know about the scientific processes? How do scientists know what they know?

- How do rocks form? What can rocks tell us about the history of Earth? Why is the study of rocks critical to understanding our Earth? What do you know about geology? What kind of rocks do you enjoy looking at?
- What do you know about asteroids and meteors? How do you think asteroids and meteors have influenced the development of the Earth?
- How do you think scientists researched dinosaur extinction? How do you think scientists uncovered the mystery of dinosaur extinction?
- What does it mean to be persistent? How do you demonstrate persistence even though something may be challenging? Why is it important to be persistent? Do you think persistence can be learned? How so?
- How does someone “make a difference?” What do you think making a difference means? Who are some famous people who have made a difference in the United States?
- What does education mean to you? Why is education important in achieving your goals? How does education provide opportunities for people?
- Was there a time when you took a chance on something? What did you do? What was the result? Was it worth taking a chance? How are taking chances important in your life?

Exploring the Book

(Reading Standards, Key Ideas & Details, Strand 1; Craft & Structure, Strand 5; and Integration of Knowledge & Ideas, Strand 7)

(Speaking & Listening Standards, Comprehension & Collaboration, Strands 1 and 2)

Book Title Exploration: Talk about the title of the book, *The Doomsday Detectives: How Walter and Luis Alvarez Solved the Mystery of Dinosaur Extinction*. Then ask students what they think this book will most likely be about and whom the book might be about. What do they think might happen? What information do they think they might learn? What makes them think that?

Read Cindy Jenson-Elliott's Biography: Cindy Jenson-Elliott is a science and writing teacher for children of all ages and adults and is the author of 18 nonfiction books for children. She is an ocean swimmer, avid gardener, and explorer of the extraordinary ordinary world. Find her online at [cindyjensonelliott.com](https://www.cindyjensonelliott.com).

Read Theo Nicole Lorenz's Biography: Theo Nicole Lorenz is the illustrator behind several books, including *Dinosaurs with Jobs*, *Unicorns Are Jerks*, and *The Trans Self-Care Workbook*. They live in Saint Paul, Minnesota with their spouse and kid, a ball python, and a pile of cats. Find more of Theo's work at [theonicole.com](https://www.theonicole.com).

Activities During Reading:

Notice and record for the ways scientists use science practices as you read:

- **Make Observations:** Scientists use their five senses, sometimes enhanced by tools, to examine the world.
- **Ask Questions:** Scientists wonder about something, and then put together a specific question to express their wonderings.

- **Modeling:** Scientists make and use models to explain how things work. Models change as their understanding changes.
- **Collaborate:** Scientists work together to answer questions and solve problems.
- **Gather Data:** Scientists gather as much information related to the question as they can. The information can be qualitative (descriptive) or quantitative (using numbers and measurements).
- **Hypothesize:** Scientists create an idea, called a hypothesis, that can be tested to explain as much of the existing data as possible.
- **Investigate, Challenge, and Test:** Scientists find ways to test hypotheses using quantitative data.
- **Analyze:** Scientists examine what all the data means, especially the new data that results from testing their hypotheses.
- **Argue Using Evidence:** Scientists present ideas and share evidence to argue why their ideas are correct. Other scientists challenge these arguments.
- **Communicate:** Scientists share their data and ideas with the world.

Using Science Notebooks: Encourage students to stop and jot in their science notebooks when they notice any of the science practices being used by scientists, or when they themselves have questions or ideas.

Conduct a phenomenon study: Observe weeds and other in your school yard. Observe animal holes in your school yard. What questions can we ask about each? What hypotheses can answer the questions?

Setting a Purpose for Reading

(Reading Standards, Key Ideas & Details, Strands 1–3)

Have students read to find out:

- who were Walter and Luis Alvarez, and how did their family's value of the importance of curiosity influence their life work?
- What were the different types of hypotheses behind why dinosaurs became extinct, and how did scientists come up with ideas of extinction?
- why do scientists test hypotheses to find out if they are UNTRUE, and not if they are TRUE?
- why was space science important to understanding what happened to the dinosaurs?
- what did scientists have to know about tsunamis to understand what happened to the dinosaurs?
- what different scientists were involved in researching the factors behind doomsday?
- why are collaboration, cooperation, and communication critical to scientific understanding?
- how are the same scientific practices used across different disciplines of research and science?

VOCABULARY

(Reading Standards, Craft & Structure, Strand 4)

(Language Standards, Vocabulary Acquisition & Use, Strands 4–6)

(Speaking & Listening Standards, Comprehension & Collaboration, Strands 1 and 2)

The story contains several content-specific and academic words and phrases that may be unfamiliar to students. Many of these words can be decoded by developing an understanding of Greek and Latin word roots. Use the following worksheet to help students explore Greek and Latin roots as they encounter words in the book. <https://docs.google.com/document/d/1Q4qHSmQW12iVKWCQqpLLiOYQ2bkS2ny-67J8zyMD8Q/edit?usp=sharing>

Based on students' prior knowledge, review some or all of the vocabulary below. Encourage a variety of strategies to support students' vocabulary acquisition: look up and record word definitions from a dictionary, write the meaning of the word or phrase in their own words, draw a picture of the meaning of the word, create a specific action for each word, list synonyms and antonyms, and write a meaningful sentence that demonstrates the definition of the word.

Content Specific

Cretaceous Period, the Age of Dinosaurs, Doomsday, Reverend William Buckland, geology, Reverend William Daniel Conybeare, fossil, Mary Anning, Lyme Regis, Plesiosaurus, *Megalosaurus*, cave dweller, Dr. Robert Plot, Thomas Pennant, Hell Creek Formation, catastrophism, Charles Lyell, *Principles of Geology*, uniformitarianism, Charles Darwin, *On the Origin of Species*, natural selection, organisms, US Geological Survey (USGS), Edward Drinker Cope, paleontology, Bone Wars, Smithsonian Museum, American Museum of Natural History, coelacanth, astrophysics, radiation, sunspots, interstellar dust, supernova, paleozoologist, astrogeologist, gradualists, catastrophists, gradualism, sedimentary, strata, Law of Superposition, Alfred Wegener, landforms, Pangaea, continental drift, sonar, mid-ocean ridge, Ring of Fire, Walter Alvarez, Luis Fernandez Alvarez, Geraldine Smithwick, Radiation Laboratory, cyclotron, cloud chamber, subatomic particles, linear accelerator, Carleton College, cartographer, Marie Tharp, Great Global Rift, plate tectonics, Harry Hess, magma, seafloor spreading, magnetic polarity, USSR, subduction zones, mantle, lithosphere, convection currents, Milly Millner, archaeological geology, atomic bomb, Bill Lowrie, Apennine Mountains, Scaglia rossa limestone, foraminifera, K-T boundary, James Hutton, *Theory of the Earth*, stratigraphic, sediment, Jura mountain range, radiometric dating, proton-rich, neutron-rich, radioactive decay, half-life, particle physics, Noble Prize in Physics, Andy Buffington, unconformity, isotope beryllium-10, Richard Muller, cosmic dust, iridium, Frank Asaro, neutron activation, bombardment, gamma ray, tektites, asteroid, impact crater, meteor, shocked quartz, Stevns Klint, Soren Gregersen, seismologist, Helen V. Michel, tsunami, impact hypothesis, Jan Smit, Jody Bourgeois, deposits, Western Interior Seaway, Greta Keller, Deccan Traps, spherules, sanidine, oceanic crust, Richard Grieve, ejecta, Thor Hansen, Florentin Maurrasse, *Discovering Alvarez*, Alan Hildebrand, drill cores, Drilling Leg 77, gravity fields, gravity anomaly, PEMEX, magnetometer, Chicxulub crater, Arroyo el Mimbral, marl, seiche waves, herbivore, carnivore, JOIDES *Resolution*, outgassing, Pincelli Hull, Christopher Lowery, Robert DePalma, Melanie A. D. During, *T-Rex and the Crater of Doom*

Academic

pollinating, mammals, predators, prey, teemed, microscopic, dynamic, gazed, terrestrial, anatomist, prehistoric, femur, embedded, curator, extinction, unpenetrated, blasphemous, evidence, speculation, evidence, evolution, inferno, hypothesis, physiology, astronomer, meteorologist, physics, skepticism, authority, mute, PhD, piqued, cavernous, festooned, acidly, gargantuan, anomaly, meticulous, conference, conglomerate, debris, vaporized

AFTER READING

Discussion Questions

After students have read the book, use these or similar questions to generate discussion, enhance comprehension, and develop appreciation for the content. Encourage students to refer to passages and/or illustrations in the book to support their responses. **To build skills in close reading of a text, students should cite textual evidence with their answers.**

Literal Comprehension

(Reading Standards, Key Ideas & Details, Strands 1–3)

(Speaking & Listening Standards, Comprehension & Collaboration, Strands 1–3 and Presentation of Knowledge & Ideas, Strand 4)

Chapter One: Earth's Greatest Mystery

1. How does the story begin?
2. Who is Reverend William Buckland?
3. What was the GeolSoc?
4. What was discussed at GeolSoc meetings?
5. What was presented at the GeolSoc meeting? Who found it?
6. What did the fossil look like? What was it called?
7. Who coined the term Dinosauria?
8. What was the earliest documentation of a possible dinosaur discovery?
9. Who was Dr. Robert Plot? What did he find?
10. What did Richard Owen, curator of the Hunterian Museum in London, hope to do?
11. What does extinction mean? What zoologist first wrote about extinction?
12. What is the Hell Creek Formation? Who explored that site?
13. Why was the idea of extinction blasphemous to many people?
14. How did Georges Cuvier present extinction in a more serious way? What did he write about?
15. What was catastrophism? How did natural theology play into catastrophism?
16. Who was Charles Lyell? What did he propose?

17. What was uniformitarianism?
18. Who was Charles Darwin? What was *The Origin of Species*?
19. What did the US Geological Survey (USGS) uncover?
20. What did Edward Drinker Cope discover?
21. What is paleontology? How did the Bone Wars impact the field of paleontology?
22. What were the four categories behind the ideas about why dinosaurs vanished?
23. How did scientists separate their beliefs in the 1970s? What did gradualists believe? What about catastrophists?
24. Who was Nicolaus Steno? What was the Law of Superposition?
25. Who was Alfred Wegener? What did he hypothesize?
26. What is continental drift and the Ring of Fire?

Chapter Two: The Question of a Lifetime

27. Where did Walter Alvarez grow up? What did he like to do?
28. Who was Luis Fernandez Alvarez? Where did he move his family from? What was his specialty in science?
29. Where did Walter Clement Alvarez grow up? How did this influence his career?
30. What became Luis's profession? Where did he end up working?
31. What was the cyclotron? What did it do?
32. What was a linear accelerator designed for?
33. Why couldn't Walter spend a lot of time in his father Luis's lab?
34. Why did Walter have to move a lot during his childhood?
35. What did Luis work on in Los Alamos?
36. Where did Walter attend college? What did he major in?
37. How was the field of geology in a major upheaval during Walter's career? What scientific advancements were occurring in geology while Walter was at Carleton College?
38. Who was conducting research on tectonic plates? Why didn't they know what happened to the cold crust?
39. What are subduction zones? How did this inform the research on plate tectonics?
40. What are plate tectonics?
41. Where did Walter attend graduate school? Why did he want to study with Professor Hess?
42. Where did Walter travel to when he worked with Professor Hess? Who did he meet during his studies?

43. Where did Walter work after graduate school? What scientist did he meet there that was also studying the movement of tectonic plates?
44. What did Walter and Bill Lowrie discover at the Appennine Mountains?
45. How did the geologic record that Walter studied begin to look different? What did Walter want to find out?
46. What is the K-T boundary?

Chapter Three: A is for Answers

47. Who was part of the A group? What did they study?
48. What are cosmic rays?
49. How was Luis as a professor? What was he like?
50. What happened to Luis in 1968?
51. What was Luis awarded for? Why?
52. Who was Andy Buffington? What kind of research did he conduct?
53. Where did Walter work in New York? What did Luis become fascinated by with Walter's work?
54. What was the Law of Superstition? How did it influence Walter's work?
55. What was Luis's idea to solve the clay layer puzzle? What kinds of techniques did he want to use to measure how much time had passed as the layers were deposited?
56. Who was Richard Muller? What did he discover?
57. What were the two ways that Walter and Luis imagined that the clay could have been deposited on top of the Cretaceous limestone?
58. What did they think came from outer space? How did they come to that conclusion?
59. What is cosmic dust? What about iridium? How did they factor into learning about the layers of clay?
60. Who was Frank Asaro? What did he help Walter and Luis with? What was Asaro known for?
61. What happened in June of 1978? What did Frank Asaro and Walter and Luis discover? Where did the source come from?
62. Who were Edward Chao and Gene Shoemaker? What did they notice about the Yucca Flats nuclear site and Arizona crater?
63. Why did geologists begin to think that catastrophism and uniformitarianism were correct?

Chapter Four: High-Impact Evidence

64. Who were the scientists Soren Gregersen and Inger Bang? What did they specialize in? How did they help Walter with learning more about the concentrations of iridium in the K-T boundary?
65. Where is Stevns Klint? Why is this an important landmark?

66. Luis and Walter wondered: what force could have left parts of the earth covered in iridium? What did they find out?
67. What is a supernova?
68. What did Dale Russell and Wallace Tucker hypothesize in 1971?
69. Who was Helen V. Michel? What did she specialize in? What did she do with the clay samples from Gubbio and Denmark?
70. Why was Walter not sure about the supernova causing the dinosaurs to die out? What did they proceed to do? What did they find out?
71. How do they think tsunamis played a role in the dinosaur extinction?
72. What did Luis wonder about asteroids and meteors and their impact on Earth?
73. How did Luis begin to formulate a hypothesis about a meteor crash on Earth and its consequences? Did he think that it could cause a worldwide extinction event? How did he work on his hypothesis?
74. What did Walter think of Luis's hypothesis?
75. Who was Jan Smit? What did he think of their impact hypothesis?
76. What was the "nastiest feud in science?"
77. What did the Alvarezes need to find on Earth to support their impact hypothesis?
78. Who were the Ulriches? What did they survive?
79. What are foraminifera? How were they important to the impact hypothesis?

Chapter Five: Closing in on a Killer: The Search for the Crater

80. Who was Jody Borugeois?
81. Where did Jody discover a sign of the K-T boundary?
82. What did Jody think of Walter and Luis's paper?
83. What did researchers question about where the iridium came from? How did scientists feel about Walter and Luis's paper about the asteroid and dinosaur extinction? What were scientists' other hypotheses about the extinction?
84. What are spherules? What do they consist of? What did Jan Smit discover about them?
85. What is shocked quartz? How is it produced? Where did Gene Shoemaker and Sandro Montanari find evidence of shocked quartz?
86. Who was Richard Grieve? What did he find?
87. When did the impact happen? How was examination of ejecta important to the hypothesis?
88. How was oceanic discovery critical to finding the crater?
89. Who was Thor Hansen? What did he find?

90. What did Florentin Maurrasse discover and identify near Beloc, Haiti?
91. What happened with Luis's health? How did Luis die?
92. Who is Alan Hildebrand? What did he study and discover?
93. What are drill cores?
94. Why did Hildebrand go to the gravity fields of the Gulf of Mexico?
95. What did they find on the Arroyo el Mimbral? What did they find here?
96. What was the significance of the Chicxulub site?
97. What did the core samples from Chicxulub from the 1950s reveal about the mystery?
98. How did the Earth begin to replenish itself after the impact? What began to grow back first?

Chapter Six: A Never-Ending Story

99. Who is Pincelli Hull? What is the JOIDES Resolution? What does Pincelli Hull work on?
100. What is the K-PG extinction?
101. What does Hull work on her in laboratory at Yale University?
102. What is the scientific process? Why are hypotheses made to be questioned, challenged, confirmed, or disproven by data?
103. What else do scientists think caused the Cretaceous extinction?
104. Why does Keller call herself a science detective of very old cases?
105. Why does Keller think there is more to the story than a massive asteroid hitting the earth?
106. What is outgassing?
107. Who is Christopher Lowery? What kind of work does he specialize in? What does he think happened with the sediments and the story of doomsday?
108. How did Lowery use radiometric dating to tell how much time passed during the crater's recovery?
109. What did Lowery's crater drilling project reveal?
110. How did scientists find where the asteroid came from?
111. What is the significance of the Tanis site? What did DePalma find at this site? What did he discover about the dinosaur footprints here?
112. What did Walter and Dr. Mark Richards wonder about the waves at the Tanis site? How did earthquakes play a role?
113. Who is Melanie Doring? What was her research focused on?
114. Why was the season the asteroid hit a factor in determining which animals survived doomsday? How did it explain why some animals survived and why some didn't?

115. What are the scientists featured in *The Doomsday Detectives* working on in present day?

116. What really happened at the end of the Cretaceous?

Each chapter includes a graphic novel section. Have students answer the following questions for each graphic novel portion of the text: The following sections are graphic novel portions of the text:

- Laws of the Land: Figuring Out How Earth Changes Over Time
- It's About Time: How History is Written in the Rocks
- It Came from Outer Space
- Big Wave Hunters
- Doomsday: The Last Day of the Cretaceous

Have students answer the following questions:

- What is this section about?
- Why is this information pertinent to the book?
- How does this information help you understand the content of the chapter you're currently reading?
- Why do you think the author chose to include this information in the graphic novel portion of the chapter?
- How do the illustrations help you to visualize the content in the book?
- What visual elements in this graphic novel section help you to understand the scientific concepts and the scientists' work presented in *The Doomsday Detectives*?

Each chapter includes a greyed-out callout box. Have students answer the following questions for each graphic novel portion of the text: The following sections are call out box portions of the text:

- Mary Anning
- Hypotheses and Scientific Practices
- Science Word Roots
- Magnetic Polarity
- Luis Alvarez and the Atomic Bomb
- The Peer Review Process
- Comics Rays
- Missing Pieces
- Asteroids, Meteors, and Comets, Oh My!

- Smoke Gets in Your Eyes
- Meeting of the Minds: Scientific Conferences
- Gravity Anomalies
- Ocean Acidification
- Diversity in US Geosciences

Have students answer the following questions:

- What is this section about?
- Why is this information pertinent to the book?
- How does this information help you understand the content of the chapter you're currently reading?
- Why do you think the author chose to include this information in this chapter?
- How do the photographs help you to visualize the content in the book?

Extension/Higher Level Thinking

(Reading Standards, Key Ideas & Details, Strands 2 and 3 and Craft & Structure, Strands 4 and 6)

(Speaking & Listening Standards, Comprehension & Collaboration, Strands 1–3 and Presentation of Knowledge & Ideas, Strand 4)

1. How were uniformitarianism and catastrophism different? Why were catastrophists and uniformitarians always arguing? Why did GeolSoc meetings become a battleground for these scientific disputes?
2. How was Charles Darwin's hypothesis about the finches on the Galapagos Islands critical to the evolution of science? What is evolution through natural selection?
3. How did a religion play a role in how people thought about science? Why do you think religion influenced people's thoughts, particularly about evolution? How does this debate influence society today?
4. What were the Bone Wars? How did scientific rivalries, featured throughout the book, influence science and create risks and rewards? How did Marsh and Cope's rivalry advance the field of paleontology?
5. How did dinosaurs become a part of mainstream media? How did Sir Arthur Conan Doyle's book, *The Lost World*, impact the role of dinosaurs in popular culture?
6. How did Professor Hess, Walter's graduate professor at Princeton University, influence his career? Why did Walter know he was at the right place on the very first day he arrived? What did he enjoy about working with Professor Hess?
7. What was Walter's "question of a lifetime?" Walter stated, "Occasionally there is a question that offers an opportunity for a really major discovery. Choosing what problems and what kind of problems to work on is a critical strategic decision for a scientist." What do you think he meant by these statements?

8. How was Walter and Luis's work with Scientist Asaro imperative to learning more about dinosaur extinction? What did they learn about clay and limestone?
9. Andy Buffington said about Luis Alvarez: "If Luis thought he was getting nonsense, he would keep at it rather acidly and not let up. It was a combination of friendly and hostile questioning." Why do you think Luis was like this? Why do you think collaborative discussions are a part of the scientific process?
10. How did the K-T layer influence Walter's work? How did clay and geology play a role in the discovery about dinosaur extinction?
11. What were some ways that Walter and Luis collaborated regarding researching the dinosaur extinction? What fascinated Walter about Luis's work, and vice versa?
12. Luis said, "The only way I could learn nuclear physics, he concluded, 'was to read everything that had been written on the subject.'" Why do you think this is a critical approach to have when studying science? Do you feel that way about any topic or hobby in your life?
13. Author Cindy Jenson-Elliott writes, "Like the weekly discussions Luis held in his living room, casual conversations are a way scientists test out ideas, get feedback, and brainstorm possibilities." How do you think these principles apply to Walter and Luis's work? What about the other scientists featured in the text? How does this relate to your own life?
14. "For an experiment to be considered valid and accurate, it must be repeatable." How do Walter and Luis demonstrate this type of scientific process in the book? Why do you think this is important for any type of scientific work?
15. Cindy Jenson-Elliott writes about Walter and Luis and their scientific process: "The scientific process was slow and painstaking. But Walter and Luis were in no hurry. They knew that good science—finding clues, measuring and analyzing data, collaborating with other researchers, and deciding how it was all connected—could take a lifetime." Why do you think it's important that the scientific process takes a long time?
16. Richard Muller wrote about Luis after his death: "Alvarez seemed to care less about the way the picture in the puzzle would look, than about the fun of looking for pieces that fit. He loved nothing more than doing something that everybody else thought impossible." What do you think he meant by this?
17. "In science, no one has the last word." How is this true in *The Doomsday Detectives*?
18. Why do you think scientific exploration is never complete?
19. What are some of the ways that the scientists featured in *The Doomsday Detectives* came together to share their talents and skills to raise awareness and research dinosaur extinction?
20. Can you think of an educator who was influential in your life? What were the qualities of that educator that made you feel welcomed, included, and confident in your own learning?
21. Why is it critical to learn about the science featured in *The Doomsday Detectives*?
22. What questions remain at the end of *The Doomsday Detectives*? What information still needs to be found out? What are scientists working on now regarding doomsday and dinosaur extinction?

- 23.** Explore the structure of this text. Was it written as chronology, comparison, cause/effect, or problem/solution, or a combination? Why do you think the author made this choice? How does *The Doomsday Detectives* compare to other books you've read?

Reader's Response

(Writing Standards, Text Types & Purposes, Strands 1–3 and Production & Distribution of Writing, Strands 4–6)

Use the following questions and writing activities to help students practice active reading and personalize their responses to the book. Suggest that students respond in reader's response journals, essays, or oral discussion. You may also want to set aside time for students to share and discuss their written work.

- 1.** What is one big thought that you have after reading this book? Think about Walter and Luis Alvarez's quest to find out about how doomsday happened. What did you learn about their processes?
- 2.** What do you think author Cindy Jenson-Elliott's message is to the reader? Think about possible motivations Cindy Jenson-Elliott's intentions in writing this book. What do you think they wanted to tell their readers?
- 3.** Have students make a text-to-self connection. What kind of connections did you make from this book to your own life? What do the scientists' questions, research, discoveries, and experiences mean to you?
- 4.** Have students make a text-to-text connection. Did you think of any other books or while you read *The Doomsday Detectives*? Why did you make those connections?
- 5.** Have students make a text-to-world connection. What kind of connections did you make from this book to what you have seen in the world, such as on television or in a newspaper? Why did this book make you think of that?
- 6.** What do the scientific practices mean to students after reading? After reading *The Doomsday Detectives*, what did you learn about the scientific practices? How have you used them in your own life? Do the scientists featured in the book inspire you to conduct your own research? How?
- 7.** What does dinosaur extinction mean to you after reading this book? What did you learn about doomsday and dinosaur extinction? Did *The Doomsday Detectives* prove any of your hypotheses about dinosaur extinction wrong?
- 8.** How has a family member or other person close to you impacted your life? There are many teachers, mentors, and family members featured in *The Doomsday Detectives* who helped each other throughout their lives. Have you had a family member, friend, or other person who really changed your life? What were some things that teacher or person did that were significant to you?
- 9.** Why are the scientists featured in *The Doomsday Detectives* important people to learn about today? How do the scientists featured in *The Doomsday Detectives* pave the way for the future of science? How did they influence our understandings surrounding dinosaur extinction?

10. At the end of the book, the author writes, "Scientists don't work for themselves; they work for everyone – everyone on the entire planet, now and in the future – to bring the truth to light and make it accessible and available to the whole world." (p. 186) After reading this book, do you agree or disagree with that statement? Why or why not? Give evidence from the book.

Multilingual Learners Teaching Activities

(Speaking & Listening Standards, Comprehension & Collaboration, Strands 1–3 and Presentation of Knowledge & Ideas, Strands 4–6)

(Language Standards, Vocabulary Acquisition & Use, Strands 4–6)

These strategies might be helpful to use with students who are multilingual learners (ML).

1. Assign ML students to partner-read the story with another classmate. Afterwards, students can create their own drawing to connect with the book's message.
2. Have each student write three questions about the story. Then let students pair up and discuss the answers to the questions.
3. Depending on students' level of English proficiency, after the first reading: 1) Review the chapters in order and have students summarize what is happening on each page, first orally, then in writing. 2) Have students work in pairs to retell either the plot of the story or key details. Then ask students to write a short summary, synopsis, or opinion about what they have read.
4. Have students give a short talk about how they connected to *The Doomsday Detectives* and what they learned about doomsday and dinosaur extinction. Students can refer to the photographs and graphic novels portions for their responses.
5. The book contains several content-specific and academic words that may be unfamiliar to students. Based on students' prior knowledge, review some or all of the vocabulary. Expose ML students to multiple vocabulary strategies. Have students make predictions about word meanings, look up and record word definitions from a dictionary, write the meaning of the word or phrase in their own words, draw a picture of the meaning of the word, list synonyms and antonyms, create an action for each word, and write a meaningful sentence that demonstrates the definition of the word.
6. Consult www.multilinguallearningtoolkit.org/ for more ideas on how to support Multilingual Learners.

Social and Emotional Learning

(Reading Standards, Key Ideas & Details, Strands 1–3 and Craft & Structure, Strands 4–6)

(Speaking & Listening Standards, Comprehension & Collaboration, Strands 1–3 and Presentation of Knowledge & Ideas, Strand 4)

(Writing Standards, Text Types & Purposes, Strands 1–2 and Production & Distribution of Writing, Strands 4–6)

(Language Standards, Vocabulary Acquisition & Use, Strands 6)

Social and emotional learning involves being aware of and regulating emotions for healthy development. In addition to understanding one's own feelings, strong socio-emotional development allows individuals to develop empathy for others and to establish and maintain relationships.

Use the following prompts to help students study the socio-emotional aspects of this book. Students can answer in partners or discussion groups or in writing.

1. How does collaboration play a role in *The Doomsday Detectives*? How do Walter and Luis collaborate with other scientists? How do they demonstrate that collaboration is critical to their work? How do you collaborate with others?
2. "He advised me to sit every few months in my reading chair for an entire evening, close my eyes, and try to think of new problems to solve." Luis encouraged Walter to brainstorm and dream. Why do you think this is important, especially in the world of science? Have you ever closed your eyes and dreamed about something you wanted? What was it like to visualize that thing? How did it make you feel? How do you think visualization helped Walter?
3. Luis and Walter encounter a lot of obstacles and setbacks in their quest to understand dinosaur extinction. How did they demonstrate resiliency after they experienced something that didn't go their way? Provide evidence from the text.
4. There were lots of different groups with varying opinions on dinosaur extinction from *The Doomsday Detectives*. When there is a topic that you don't know a lot about, how do you go about finding out information about that topic? In *The Doomsday Detectives*, how did Walter and Luis use ideas from all different groups in creating their hypotheses? Why is it important to look at multiple viewpoints when solving a problem?
5. Luis Walter Alvarez stated, "I am convinced that a controlled disrespect for authority is essential to a scientist. All the good experimental physicists that I have known have had an intense curiosity that no Keep Out sign could mute." What do you think he meant by this? Why do you think pushing the boundaries in science helped Luis solve scientific problems?
6. Walter Alvarez stated, "Occasionally there is a question that offers an opportunity for a really major discovery. Choosing what problems and what kind of problems to work on is a strategic decision for a scientist." How does Walter's philosophy apply to your own life? Have you ever had to choose what to work on first? How does this affect you mentally? How do you sort what challenges to work out?
7. How are hypotheses critical to research and science? Why do you think it's important to first come up with a hypothesis instead of diving into research without one? How do you use critical thinking and problem-solving skills when you're coming up with a hypothesis? How did the scientists featured in *The Doomsday Detectives* use their own social and emotional learning skills in generating hypotheses of their own?
8. Many of the scientists, including Luis and Walter Alvarez, experience disappointment in *The Doomsday Detectives*. Find instances of when the scientists go through disappointment. How did they recover from their disappointment? What were some of the things that they did to rebound? How do you overcome disappointment? What did you learn from the scientists in *The Doomsday Detectives* about experiencing disappointment?
9. How do you think Luis influenced Walter as his father? Have you ever been influenced by a family figure? How do they inspire you?
10. Describe the qualities of Luis and Walter's relationship. What are some of the positive aspects of their relationship that are thrown throughout the book?
11. Why is it sometimes difficult to express yourself and make choices without worrying about

what others think? Do people's opinions or thoughts affect how you think about yourself? Why or why not?

12. Describe a time that you or someone you know made a choice without worrying about what other people said and/or did. How did it make you feel? What advice might you give to someone who is always worried about what other people say and/or do?
13. Choose an emotion that interests you: happiness, sadness, frustration, anger, etc. Discuss or write about what that emotion looks like in *The Doomsday Detectives*.

INTERDISCIPLINARY ACTIVITIES

(Introduction to the Standards, page 7: Students who are college and career ready must be able to build strong content knowledge, value evidence, and use technology and digital media strategically and capably)

Use some of the following activities to help students integrate their reading experiences with other curriculum areas. These can also be used for extension activities, for advanced readers, and for building a home-school connection.

English/Language Arts

(Reading Standards, Key Ideas and Details, Strands 1–3, Craft and Structure, Strands 4–6, Integration of Knowledge & Ideas, Strands 7–9, Range of Reading of Text Complexity, Strand 10)

(Writing Standards, Text Types & Purposes, Strands 1–3, Production & Distribution of Writing, Strands 4 and 6, Research to Build & Present Knowledge, Strands 7–9, Range of Writing, Strand 10)

(Speaking and Listening Standards, Comprehension and Collaboration, Strands 1–3, Presentation of Knowledge and Ideas, Strands 4–6)

- **Have students select a quote from one of the scientists in the book and write a reaction to it.** Who was the scientist they chose, and why? Why did they choose to write about that quote? What are their reactions to those statements? How does this quote reflect that work that goes into research and scientific processes?
- **Cindy Jenson-Elliott writes: “But challenging hypotheses is how science works, and in the end, scientists celebrate new and better explanations, even when data proves their own ideas wrong.”** Find evidence of situations where scientists are proven wrong in the book, and how different discoveries come out of those incorrect hypotheses. Consult the “A Guide to Scientific Practices” that begins *The Doomsday Detectives*. How do you think this guide was influential in your reading of the book? Why do you think Cindy Jenson-Elliott created this guide for students? What ways were the scientists wrong, and what did they do to counteract that incorrect hypothesis? Students can write an essay detailing their thoughts in an essay.
- **Ask students: What can *The Doomsday Detectives* teach us?** Have students share their findings. What lessons did the book teach readers over the course of the book? What did they learn from the story's message? Students can talk with partners, in small groups, or with the whole class. Consider creating a word cloud to find out what words came up the most often (<https://www.wordclouds.com>). Then students can come up with a big idea or statement about what they learned from *The Doomsday Detectives*.
- **Have students write a biography on Luis or Walter Alvarez.** Students can pick Luis or Walter Alvarez from *The Doomsday Detectives*. After their selection, students can

use the Biocube tool to plan their biographies (<https://www.plainville.k12.ma.us/cms/lib/MA01000200/Centricity/Domain/268/Biography%20Cube%20Template.pdf>). Have students answer the following guiding questions: why did you pick this scientist? When were they born? Where did they grow up? What additional information did you find from your research that was not included in *The Doomsday Detectives*? What field of science did they specialize in? What were some of their groundbreaking findings? How did they contribute to the world of science at large? Students can write about Luis or Walter in an essay or an informational poster, providing their sources and findings in an accompanying bibliography. Use the Lee & Low Books' Biography Toolkit with graphic organizers to take notes, organize thoughts, and analyze the text: <https://www.leeandlow.com/wp-content/uploads/2025/01/Biography-Toolkit-2.pdf>.

- **Have students choose one of the scientists from the book to conduct additional research on.** In addition to Walter and Luis Alvarez, there are many other scientists featured in *The Doomsday Detectives*. Students can answer the following questions: what is this trailblazer known for? Why did you select this trailblazer to conduct additional research on? What organizations are they affiliated, or did they start? What kind of adversity have they encountered in their work? How have they experienced success? Students can prepare a visual presentation with additional documentation, such as photos, videos, and other resources to share with the class. Consult the Lee & Low Biography and Biocube tool for additional support.
- **Come up with questions to interview the author, Cindy Jenson-Elliott.** What was her process behind creating *The Doomsday Detectives*? What was her inspiration for the book? How did her science teaching background play a role in the writing of the book? What made her want to write about dinosaur extinction? Consider reaching out to Cindy Jenson-Elliott for an author visit, either in person or virtually ([cindyjensonelliott.com](https://www.cindyjensonelliott.com)).
- **Write a comic, in the style of *The Doomsday Detectives*, about a topic they learned about in the text.** Have students select a topic (the same topic that they will choose for their informational project in the Science/STEM section of this guide) and write a comic dedicated to that topic. Students can include the information that they learn during their investigation to incorporate in their comic strip. The Kennedy Center's "Creating Comic Strips" has lesson plans and resources dedicated to teaching students about how to write comics (<https://www.kennedy-center.org/education/resources-for-educators/classroom-resources/lessons-and-activities/lessons/3-5/creating-comic-strips/>).
- **Encourage students to prepare a presentation or write an essay about an interest, hobby, and/or activity that they're passionate about.** Walter and Luis Alvarez both loved science and investigating the dinosaur extinction. Do you have an interest in something like Walter and Luis? Why is this important to you? Have students share their findings with a partner, small group, or whole class.
- **Encourage students to look for the books in the Source Notes in the Backmatter of *The Doomsday Detectives*.** How are these books critical for learning about dinosaur extinction and the history of dinosaur research? Have students select a book from the list or another book that interests them and have them find the book at their local and school library.

- **Learn about bibliographies and how to cite sources.** ReadWriteThink's "Research Building Blocks: Cite Those Sources!" is a lesson plan on teaching students how to cite their research and understand bibliographies and why they're important (<https://www.readwritethink.org/classroom-resources/lesson-plans/research-building-blocks-cite>). Have students look through the Backmatter of *The Doomsday Detectives* before conducting their own research projects, featured in different sections of this guide, to inform their own bibliography development.
- **Select one of the grey callout boxes from *The Doomsday Detectives* about and conduct a research project about that topic.** There are specific terms and topics in *The Doomsday Detectives* that have designated callout boxes for more information. Students can choose one of the grey callout boxes to learn more. Why did students select that term? What else can they learn about that topic, for example, "Ocean Acidification?" Why do they think this term had a callout box?
- **Encourage students to read the blurbs for *The Doomsday Detectives* and write their own review of the novel.** *The Doomsday Detectives* has received three starred reviews. What would students want to include in their review? What do they want to tell other readers about this book? How did it affect them? For ideas, check out this Book Review Template (<http://www.readwritethink.org/classroom-resources/printouts/book-review-template-30200.html>) by ReadWriteThink.org. For a list of the reviews for *The Doomsday Detectives*, consult the book page at leeandlow.com/the-doomsday-detectives and at the end of this guide.
- **Have students unpack the comic strip portions of *The Doomsday Detectives* and write a comparison essay about reading the graphic novel section versus the prose sections.** Why do you think the comic strip format was used to tell specific parts of the book? Why do you think Cindy Jenson-Elliott wanted to use comics throughout *The Doomsday Detectives*? What do readers gain by experiencing the story visually as well as through words? Students can write an essay detailing their findings. For more information on graphic novels and how to teach about graphic novels, consult "How to Study Comics & Graphic Novels" (<https://www.torch.ox.ac.uk/files/howtostudycomicsgraphicnovels-agraphicinroductiontocomicsstudiespdf>). Edutopia's "Using Graphic Novels and Comics in the Classroom" also provides helpful tips on getting started with graphic novels in educational settings (<https://www.edutopia.org/blog/graphic-novels-comics-andrew-miller>).

Discussing Graphic Nonfiction

Because *The Doomsday Detectives* has elements of a graphic novel, there are some unique elements of the medium that students need to understand to comprehend the story. Incorporate these questions into discussions:

1. Point to where you see these elements of a graphic novel on the page: panels, frame, gutter, speech balloon, thought balloon, caption, special-effects lettering, foreground, background. How would the story change if you took out any one of these elements?
2. Graphic novels use both words and illustrations. What do you learn from just the words on this page? What do you learn from just the illustrations? Are they telling you the same or different information? How do they work together?

3. Expressions and gestures are important to how we understand characters. Have students select a character. Then encourage students to look for an example of a particular expression or movement that you think shows a significant character trait.
4. In graphic novels action happens “in the gutters,” or in the spaces between each panel. Sometimes big things happen in the time it takes to turn the page. Find a specific sequence of panels or a page turn and explain what actions or events happened in those in-between spaces or gutters. How do we know those actions took place if we don't see them?
5. In graphic novels, panels are used to show the passage of time. Time, and how fast or slowly it seems to pass, is important in how panels change. Can you find a sequence where the pacing is slow, observing a character or scene? How about a sequence in which everything speeds up?
6. What's the difference between genre (science fiction, realism, etc.) vs. medium (graphic novel, novel, poetry)? Why do you think Cindy Jenson-Elliott chose to tell this story with elements from a graphic novel?
7. As a follow-up activity, show students the graphic novel sections of the text without the chapters. See if students can complete a story without the context of the chapters. What kind of story would this be without the additional information from the chapters? How would students tell the story with just the graphic novel portions of the book?

Science/STEM

MS-ESS1 Earth's Place in the Universe: MS-ESS1-4 Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history; MS-ESS2 Earth's Systems; MS-ESS2-2 Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales; MS-LS4 Biological Evolution: Unity and Diversity MS-LS4-1 Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past; MS-LS4-2 Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships.

- **Select a topic presented in the Source Notes section of *The Doomsday Detectives*.** Students can answer the following guiding questions about that topic: Students can answer the following questions: why did you select this topic to conduct additional research on? What research and information is presented in the book about this topic? What scientists researched or worked on this topic? How does this relate to doomsday and dinosaur extinction? What resources were provided in the Source Notes? How were they helpful in learning more about this topic? Students can prepare a visual presentation with additional documentation, such as photos, videos, and other resources to share with the class.
- **In groups, have students make a posterboard detailing the steps to the Alvarez's doomsday project and the results.** Using evidence from the text, have students create a step-by-step guide to how Luis and Walter Alvarez came up with their theory behind dinosaur extinction. Students can refer to the resources and Glossary in the back of the book for more information. Afterwards, students can create posters or other visual presentations providing details about the steps and connect it back to the scientific method. What was the original hypothesis proposed by Walter and Luis? What were their next steps? Did Walter and Luis ever differ on their thoughts? What other scientists were involved? Students can showcase visually how they came up with their final theory on their posterboard.

- **Learn more about the different periods that dinosaurs lived in and create a timeline.** The American Museum of Natural History has a PDF and lesson plan dedicated to guiding educators through creating a timeline featuring dinosaurs. Students can refer to the graphics in *The Doomsday Detectives* to inform their timeline research. Additional resources include The National History Museum's "When did dinosaurs live?" (<https://www.nhm.ac.uk/discover/when-did-dinosaurs-live.html>) and USGS's Youth and Education in Science page (<https://www.usgs.gov/youth-and-education-in-science/mesozoic>) has more details on the dinosaur periods.
- **Have students conduct a research study on how geology impacted the research behind doomsday.** Students can go through *The Doomsday Detectives* and note all the different ways that the scientists used geology to inform their hypotheses and research that went into doomsday. How were rocks behind the discovery of the dinosaur extinction? Online resources include Dr. Andrea Dutton's article "What Really Killed the Dinosaurs?" (<https://geology.ufl.edu/news/2016/what-really-killed-the-dinosaurs/>) and Dr. Pincelli Hull's article: "On Impact and Volcanism across the Cretaceous-Paleogene Boundary." <https://www.science.org/doi/full/10.1126/science.aay5055> Both scientists study the same thing -- the impact of oceanic volcanic eruptions and an asteroid impact -- and come to slightly different conclusions. How did they study the question of how each event impacted the Cretaceous extinction? Additional information can be found in the Source Notes section of *The Doomsday Detectives*. Students can present their findings in a visual poster with photographs and other sources of information.
- **Find out how iridium at the K-Pg boundary played a critical role in figuring out dinosaur extinction.** Students can answer the following questions: what is iridium? Where is iridium usually found on planet Earth? Why did the scientists think it may have come from outer space? How is iridium integral to doomsday? How did Walter and Luis Alvarez incorporate iridium in their research? Regarding the K-Pg boundary, students can answer the following questions: what is the K-Pg boundary? Where is it located? Why was it important to discovering what happened to the dinosaurs? How are iridium and the K-T boundary connected? Students can look at iridium and the K-T/K-Pg boundary in sources provided in *The Doomsday Detectives* and online at the Lunar and Planetary Institute's "Understanding the K-T Boundary" (<https://www.lpi.usra.edu/science/kring/Chicxulub/#:~:text=Like%20meteorites%2C%20asteroids%20and%20comets,1095%2D1108%2C%201980>) and UC Berkeley's "The K-T Extinction" (<https://ucmp.berkeley.edu/education/events/cowen1b.html>).
- **Research the different geological and atmospheric factors that influenced dinosaur extinction, including plate tectonics, tsunamis, and earthquakes.** UC Museum of Paleontology's "Asteroids and dinosaurs" has more details and lesson ideas on teaching resources about how plate tectonics had a role in dinosaur extinction (<https://undsci.berkeley.edu/asteroids-and-dinosaurs-unexpected-twists-and-an-unfinished-story/>). Tsunamis and earthquakes' impact on dinosaur extinction can be found at the following resources: NOAA's tsunami simulation (<https://sos.noaa.gov/catalog/datasets/tsunami-asteroid-impact-66-million-years-ago/>) and Penn State's Dutton Institute "The Tsunami that Killed Dinosaurs!" (<https://www.e-education.psu.edu/earth107/node/1623>).

- **Have students investigate how *The Doomsday Detectives* revealed all these different factors that played into dinosaur extinction, and how they influenced scientists' hypotheses and scientific processes into learning about doomsday.** Which scientists were behind the tsunami theory? Which scientists were behind the earthquake theory? How did Luis and Walter Alvarez use all this information into formulating their beliefs and hypotheses about what happened to the dinosaurs?
- **Discuss the importance of the Chicxulub impact crater in the doomsday research study. The University of Texas's Institute for Geophysics has resources and photos from Chris Lowery about the impact crater** (<https://ig.utexas.edu/marine-and-tectonics/chicxulub-crater/>). The Lunar and Planetary Institute has more online photos and resources about the impact crater (<https://www.lpi.usra.edu/science/kring/Chicxulub/discovery/>). Students can use *The Doomsday Detectives* to write an essay about how the impact crater was discovered and its importance in the doomsday project. Who discovered the impact crater? What scientists were involved? What did it mean to find this crater? How is this crater influential in doomsday research today?
- **Investigate the different sites throughout the world that the Alverezes and other scientists traveled to throughout *The Doomsday Detectives*.** Where did the Alvarez go to research meteor impacts, sedimentary deposits, and the K-T boundary? Where did scientists study tsunamis and dinosaurs? Students can plot their research points on a map to show the different areas in the world where they went to learn more about how geology played a role in dinosaur extinction.
- **Conduct a scrolling magnetic reversal model.** This video about magnetic reversals explains magnetic reversals and sea floor spreading (<https://www.youtube.com/watch?v=BCzCmlDiaWQ>). NOAA's "Seafloor Spreading Activity" (https://oceanexplorer.noaa.gov/edu/learning/2_midocan_ridges/activities/seafloor_spreading.html) provides questions and ideas on how to teach about seafloor spreading to students. Students can discuss the role of magnetic reversal in dinosaur extinction. The Woodside Australian Science Project has ideas on how to recreate the magnetic reversal model using everyday materials (https://www.wasp.edu.au/pluginfile.php?file=%2F360%2Fmod_resource%2Fcontent%2F2%2FMagnetic%20Stripes%20%E2%80%93%20Student%20Activity.pdf). American Geosciences also has a lesson plan dedicated to teaching about Earth's Magnetic Memory Revealed in Seafloor Cores (https://www.americangeosciences.org/static/files/education//ocean-coring/BeyondSurface_Teacher_250110.pdf).
- **Create a Pangea puzzle.** The Florida Museum's Pangea Puzzle provides more ideas on activities and worksheets on creating a Pangea puzzle (<https://www.floridamuseum.ufl.edu/educators/resource/pangea-puzzle/>). As students are creating the puzzle, have them reflect on what they learned about Pangea from *The Doomsday Detectives*. Who first observed that the continents were once part of one piece called Pangea? How did they gather data to fit this theory? How does Pangea affect how we learn about the Earth today?

Social Studies/Geography

(Reading Standards, Key Ideas and Details, Strands 1–3, Craft and Structure, Strands 4–6, Integration of Knowledge & Ideas, Strands 7–9, Range of Reading of Text Complexity, Strand 10)

(Writing Standards, Text Types & Purposes, Strands 1–3, Production & Distribution of Writing, Strands 4 and 6, and Research to Build & Present Knowledge, Strands 7–9, Range of Writing, Strand 10)

(Speaking and Listening Standards, Comprehension and Collaboration, Strands 1–3, Presentation of Knowledge and Ideas, Strands 4–6)

- **Have students select a scientist featured in *The Doomsday Detectives*. They can answer the following questions about the scientist:**
 - What scientist is featured in this chapter?
 - What is the scientist known for?
 - What accomplishments and accolades does the scientist have?
 - What obstacles did the scientist have to overcome?
 - What organizations does the scientist work with?
 - What is this scientist working towards?
 - What does this scientist hope for the future?
 - What time period does/did this scientist live in?
 - Students can present their findings in an informational poster with answers to the questions, in addition to a bibliography that provides their sources. Use the Biocube tool and Lee & Low Biography toolkit from the English Language Arts section of this guide to inform students' thinking and development of their biographical pieces.
- **Create a timeline for the history of the doomsday project.** Have students organize the events along a timeline to discuss their thoughts/knowledge on the progression of history related to the science behind figuring out doomsday. How did these specific events shape learning about doomsday and how the dinosaurs became extinct? How did the time influence the research about dinosaurs? How did research change throughout the history during *The Doomsday Detectives*? Students can work in groups and use the information presented in *The Doomsday Detectives* to create their own timelines to present around the classroom.
- **If possible, attend a local museum or virtual exhibits featuring dinosaurs.** The National History Museum has an exhibit titled, "Virtual Tour of Dino Hall" (<https://nhm.org/stories/virtual-tour-dino-hall-english>). The Smithsonian National Museum of History allows visitors to take a virtual walk-through of the entire museum (https://naturalhistory2.si.edu/vt3/NMNH/z_tour-022.html). The Smithsonian Museum also has a YouTube video exploring the Hall of Fossils specifically for students (<https://www.youtube.com/watch?v=s1Ygz3vYrgo>). The Natural History Museum of Los Angeles County has a virtual tour with ASL accommodations (<https://nhmlac.org/stories/virtual-tour-dino-hall-asl>). Edutopia's "Getting the Most out of Field Trips" (<https://www.edutopia.org/article/museum-field-trip-activities/>) provides more tips, strategies, and ways to guide effective lessons centering museums.

Art/Media

(Reading Standards, Integration of Knowledge and Ideas, Strands 7 and 9)

(Writing Standards, Text Types & Purposes, Strands 1-3, Production & Distribution of Writing, Strand 4, and Research to Build & Present Knowledge, Strands 7-9, Range of Writing, Strand 10)

(Speaking and Listening Standards, Comprehension and Collaboration, Strands 1-3, Presentation of Knowledge and Ideas, Strands 4-6)

- **Come up with questions to interview the illustrator, Theo Nicole Lorenz.** What was their process behind creating the illustrations for *The Doomsday Detectives*? Why did they choose a particular artistic medium to create the illustrations? What was their inspiration to depict the dinosaurs, scientists, and other scientific topics in the way that they did in the book? What were some of their favorite illustrations and why?
- **Have students create their own fossils. The National Park Service's "Make Your Own Fossils" has tips and ideas on how students can create their own** (<https://www.nps.gov/teachers/classrooms/make-your-own-fossils-lesson.htm>). Penn State's "D.I.Y. Plant Fossils" (<https://pollinators.psu.edu/assets/uploads/documents/DIY-Plant-Fossils-Lesson-AG-SEEDLINGS.pdf>) is a lesson plan designed to teach students about fossils and then using plants to create their own.
- **Photocopy pages of one of the comic strip sections of *The Doomsday Detectives*, selecting one with multiple panels in a plot sequence.** Cut the panels apart and shuffle them so they are out of order. Place the mixed-up panels into an envelope. Prepare the adequate number envelopes you need to distribute them to pairs of students. After collecting their books, have students work in pairs to organize the panels in proper sequence. Prompt students to use cues and context provided by the illustrations and text, as well as their recall of the story. Walk around asking questions and giving feedback. Have students use their books to check their work.
- **Analyze the cover art for *The Doomsday Detectives*.** Why do you think the illustrator portrayed Walter and Luis in this way? How are the different themes from the story shown on the cover? Have students write an essay about the ways that covers can influence how they perceive the characters in the book.
- **Encourage students to select an illustration that resonated with them the most from *The Doomsday Detectives*.** Have students write a reflection about the illustration. What stood out to them? How did it make them feel? What did it make them think about?
- **Write an essay about the power of graphic novels. How do graphic novels help you visualize the scenes throughout the book?** What would it have been like to read *The Doomsday Detectives* without the comic strip sections? Students can read the following articles about the importance of graphic novels to get started: Markham Public Library's "5 Benefits of Reading Graphic Novels" (<https://markhampubliclibrary.ca/blogs/post/5-benefits-of-reading-graphic-novels/>) and *The New York Times*' "How Graphic Novels and Comics Can Move a Story" (<https://www.nytimes.com/2018/05/28/insider/graphic-novels-comics-book-review.html>).

School-Home Connection

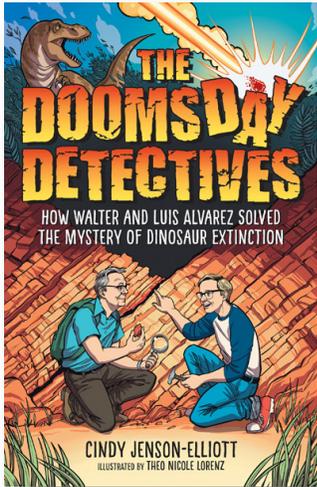
(Reading Standards, Integration of Knowledge and Ideas, Strands 7 and 9)

(Writing Standards, Text Types & Purposes, Strands 1-3, Production & Distribution of Writing, Strand 4, and Research to Build & Present

Knowledge, Strands 7-9, Range of Writing, Strand 10)

(Speaking and Listening Standards, Comprehension and Collaboration, Strands 1-3, Presentation of Knowledge and Ideas, Strands 4-6)

- **Ask students to interview their caregivers about a time they faced a significant obstacle.** The scientists working to research doomsday demonstrate a lot of persistence and commitment. How did they overcome it? What made them persist in reaching for their goal? What advice do they have for someone who must tackle a challenge? Why is persistence important? Students should write the answers from the interview and be prepared to share in class.
- **Have students share the online museum virtual tours from the Social Studies section of this guide with caregivers.** Students and caregivers can discuss what they know about dinosaur extinction, and what they can learn from these dinosaur exhibits. Students can talk about what they learned about dinosaur extinction from *The Doomsday Detectives* with their families.
- **Learn more about Walter and Luis Alvarez and their contribution to the sciences.** Share with caregivers about who Walter and Luis Alvarez were, if they weren't familiar with these scientists, and how they wanted to solve the doomsday question. Students can share the following online resources about Walter and Luis Alvarez (<https://www.pbs.org/wgbh/aso/databank/entries/do80di.html>) and how the father and son duo influenced the conversation about dinosaur extinction for years to come.



Ordering Information

General Order Information:

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ABOUT THE AUTHOR

Cindy Jenson-Elliott is a science and writing teacher for children of all ages and adults and is the author of 18 nonfiction books for children. She is an ocean swimmer, avid gardener, and explorer of the extraordinary ordinary world. Find her online at cindyjensonelliott.com.

ABOUT THE ILLUSTRATOR

Theo Nicole Lorenz is the illustrator behind several books, including *Dinosaurs with Jobs*, *Unicorns Are Jerks*, and *The Trans Self-Care Workbook*. They live in Saint Paul, Minnesota with their spouse and kid, a ball python, and a pile of cats. Find more of Theo's work at theonicole.com.

Reviews

"Using the framework of the scientific process to structure the content, Jenson-Elliott effectively builds on explanations that contextualize the major concepts that drive the Alvarezes' discovery. . . . Emphasizes the thrill of these discoveries, which are made all the more thrilling by the fact that there is still so much more to learn. Perfect for kids who want to go all-in on dinosaurs."—**Booklist, starred review**

"Packed with explanations of scientific terminology and methods of operation, this detailed and compelling book is a superb guide for curious STEM-focused readers. An outstanding resource that depicts the winding and complex journey of scientific exploration."—**Kirkus Reviews, starred review**

"An excellent, format-defying nonfiction introduction to the origins of paleontology and the quest to solve the mystery of dinosaurs' extinction. . . . Purchase this impressive STEM title for dino fans, curricular tie-ins, and all nonfiction shelves."—**School Library Journal, starred review**

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