

## **Chapter Summary Questions**

These questions can be used to help students identify and better grasp what was most important in each chapter. They could also be used for a quiz.

### Before introducing the book

How can we learn from fossils?

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### Introduction

What drew the author, who is not a scientist by trade, to write this book about science?

Why does the author say the group of people involved in this book were “a quirky band of boundary-bending collaborators that looked more like a roots-rock band than ivory tower intelligentsia?”

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### 1: Lasting Impressions

Why do scientists estimate that many, many more species of life existed on Earth than fossils represent?

True or false, when an animal is fossilized, all of its remains are found? Why?

Why would only the fossilized teeth of a shark be found (why not its ribs, spine, etc.)?

Why were only 32 of the 140 dinosaur species Marsh and Cope identified during their “Bone Wars” proven valid?

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### 2: The Shark Bites

How was it determined that fossils were remains of past life?

What is a Chedworth bun and how does it relate to fossils?

Explain the Principle of Superposition in geology.

What is faunal succession?

How did observation of evidence lead to William Smith’s understanding of faunal succession?

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### 3: Right Shark, Wrong Name

How did Henry B. Woodward misidentify evidence in a photo of the Australian fossil?

What is the two name system devised by Carl Linnaeus to classify plants and animals and what does each part of that system refer to?

What are all eight levels used for classifying animals and plants?

What is the class in which all fish with cartilaginous skeletons (including sharks) belong?

What does the word homologous mean in comparative anatomy?

How are divergent and convergent evolution different in terms of comparative anatomy?

What is the difference between analogous and homologous structures in comparative anatomy?

In 1868 Leidy worked with a sculptor to create a display of real dinosaur bones. What was significant about this event?

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### 4: First Cousins

During the second half of the 1800's, several individuals observed fossil evidence and presented well-supported arguments as to what the fossil represented - teeth or fin spines.

What evidence caused Leidy to think that his fossil came from the upper jaw of a shark?

Why did the bilateral symmetry of the fossils confuse researchers and cause them to believe they were not teeth?

How did the Civil War affect the study of fossil sharks?

What is denticle?

What arguments based on fossil evidence does Newberry provide supporting fin spines?

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### 5: Whorl of Fortune

In this chapter the author introduces new fossils and an important new researcher, Karpinsky. Both the fossils and Karpinsky are from Russia. The chapter turns into a tour of geologic time and picks up with Karpinsky's role as a geologist again at the beginning of chapter 6.

How and where were new and more complete tooth whorl fossils found?

The geologic timescale is described from pages 81- 93. At what point in geologic time did *Helicoprion* exist? How do we know?

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#### 6: Karpinsky Makes the Call: *Helicoprion*

This chapter represents a turning point in *Helicoprion* research history when it is definitively given its own genus by Karpinsky.

What are some of the observations Karpinsky made by examining the Russian whorl fossils?

Compare and contrast spiral patterns found in nature. How are they similar? How are they different? What other examples of natural spiral patterns can you think of?

What does the name *Helicoprion* mean?

Why did Karpinsky classify the Russian and Australian fossils as different species of *Helicoprion*?

What was Karpinsky able to learn about the fossils using polarized light microscopy (and what is it)?

Why did Karpinsky admit what he didn't know in his paper?

How did the debate sparked by Karpinsky's paper help move scientific understanding about *Helicoprion* forward?.

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#### 7: A Shiver of Sharks

Why did several new fossil specimens appear after Karpinsky's 1899 paper?

Why did Eastman determine that whorls were singular, rather than multiple, per animal?

Explain why Idaho yields more *Helicoprion* fossils than anywhere else in the world.

Explain how additional fossil specimens and various published papers following Karpinsky's 1889 paper led to the advance of understanding of *Helicoprion* (use specific examples).

What fossil evidence finally convinced scientists that they were looking at teeth, not fin spines of *Edestus*?

What evidence supported Hay's idea that each animal only had one set of blades, centered in their mouths?

Did the study of *Helicoprion* advance during World War I?

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### 8: Signs of Life

This chapter picks up with new fossil discoveries after over two decades without much movement on *Helicoprion* research. It introduces some initial discoveries (made using the tools available at the time) for certain fossils that become important later in the story.

What is a fossil mold?

How did *Helicoprion* fossils found in the Sierra Nevada (California and Nevada) help date the rock strata there?

What is a zone or indicator fossil?

What is a concretion?

What did Bendix-Almgreen discover about the fossil specimen named Idaho 4 that was special?

What is tessellated cartilage?

What did lack of strong wear marks on the tooth whorl fossils provide evidence for or against, according to Bendix-Almgreen's observations?

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### 9: The Art of Obsession

On page 144 artist Ray Troll's writer friend told him, "if you can explain a concept to your bartender you're a good writer." What does that mean in terms of *Helicoprion*?

Why are science illustrators important? Why is it important that they be up to speed on the latest research?

Should science illustrators work as accurately as possible, or is it okay for them to incorporate their own style? Why or why not?

Discuss "artistic license" vs. scientific detail...

Scientist Rainer Zangerl told Ray Troll, "zee oldest teese are at the zee zenter of ze whorl." In your own words, explain how *Helicoprion's* tooth whorl grew.

How does Ray Troll's and scientists Zangerl and Bendix-Almgreen back and forth about Troll's drawings or *Helicoprion* fit into [the process of science](#)?

Was the debate about how *Helicoprion*'s tooth whorl fit into its head settled by the mid 1990's?

Why was Ray Troll hesitant to listen to Richard Lund's scientific opinion about removing the gill slits on his *Helicoprion* drawing? What was the fossil evidence that Richard Lund used to support removing the gill slits from the drawing?

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#### 10: The New Guard

Why did the arrangement of land on Earth during the Permian look so different from today?

What fossil evidence did Lebedev find to determine how *Helicoprion* used its tooth whorl for feeding?

How did Lebedev reason between fossil evidence and the hypothesis that *Helicoprion* was a squid hunter?

What is taphonomy and how does it relate to Pruitt's study of *Helicoprion*?

Why is important to conduct a thorough review the scientific literature about a topic before beginning new scientific research?

Why were other scientists unhelpful/skeptical of Pruitt's interest in researching *Helicoprion* at first?

What were Pruitt's and Tapanila's backgrounds coming into the *Helicoprion* project? Did either of them set out to study *Helicoprion*?

What was Jesse Pruitt's original research goal in the *Helicoprion* research project?

What did Pruitt and Tapanila discover about the 85th tooth on a *Helicoprion* tooth whorl?

What was important about Bendix-Almgreen's 1966 paper that was the key to moving Pruitt's research project forward?

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#### 11: Resurrection, One Slice at a Time

Why was the re-discovery of calcified cartilage by Jesse Pruitt in 2010 in the Idaho No. 4 fossil so important?

What is CT scanning technology and how is it used in paleontology?

Where did the money for CT scans of the *Helicoprion* fossil come from? Why?

What did Pruitt and Schlader do for “proof of concept”?

How did Pruitt and Schlader create a 3-D computer model from the CT scan slices?

What role did Alan Pradel play when he was first brought into the project?

What new questions about *Helicoprion* did the new 3-D model bring up?

Why did Ray Troll suggest that Pruitt, Schlader and Tapanila contact Cheryl Wilga, an expert on modern shark jaws?

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## 12: Coming to Terms

How does the operation of human jaws compare to that of shark jaws?

How do scientists think jaws evolved?

Explain the two theories of the evolution of teeth.

What is functional morphology?

Why were Pruitt and Tapanila willing to share their data with Cheryl Wilga and Ramsay?

Explain examples of how Pruitt and Tapanila, Didier, Pradel, Wilga and Ramsey used the scientific practice of argument based upon evidence.

Pradel wanted to focus on *Helicoprion*'s jaw suspension. Why did this worry Ray Troll?

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## 13: To the Summit and Beyond

Why was it important that the scientists working together to learn about *Helicoprion* meet in person?

What did each member of Team Helico at the Shark Summit in October 2012 bring to the table?

What was the goal of the Shark Summit?

Summarize what conclusions the team came to about *Helicoprion* after all their collaboration and the two-day Shark Summit.

How many publications came out of the Shark Summit?

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14: Shark is a Verb

Why is this chapter called “Shark is a Verb”?

How is the process of science reflected in the author’s quote about Team Helico’s findings, “okay then, prove us wrong” on page 244?

Should Team Helico be annoyed that other scientists took exception to their findings?

Does it matter if we know if *Helicoprion* had gill slits? Why or why not?

What is necessary to definitively determine whether or not certain pieces of Ray Troll’s most educated reconstructions of *Helicoprion* are accurate?

Do scientists know when and why *Helicoprion* went extinct? Why or why not?

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