



## **Cabrillo Marine Aquarium Lesson Plan**

**Grade Level:** Fifth and Eighth Grades

**Title:** *JAW-normous: A Lesson on the Biggest Shark that Ever Lived!*

**Objective:** Megalodon is believed to be the largest shark to have ever lived! But just how big was Megalodon? In this lesson, students will determine Megalodon's size using the same methods as research & field scientists. This lesson will allow students the opportunity to estimate the body length of Megalodon based on modern shark models. Students are provided with actual data from which they will construct a graph demonstrating the relationship between living shark tooth width and body length. The resulting graph will then be used to estimate the body length of Megalodon.

**California Science Standards:** 5<sup>th</sup>: 2a, 6a-i 8<sup>th</sup>: 9a-g

**Time to Complete:** 45 to 60 minutes

**Materials Provided by CMA:** *Reading Handout: How Megalodon Worked; Worksheet: Megalodon - Biggest Shark that Ever Roamed the Seas, Worksheet: Megalodon Crossword Puzzle*

**Materials Provided by Teacher:** Photocopies, drawing paper & pencils.

**Vocabulary:** Allometric, cartilage, cartilaginous, centrum, fossilization, morphology, ossification, null hypothesis, independent variable, dependent variable

**Background Information:** Complete shark skeletons are not found in the fossil record. This is because sharks have cartilaginous skeletons (i.e., composed of cartilage), which will rarely fossilize. Instead, scientists often only find fossilized shark teeth and/or ossified (i.e., boney) shark centra (i.e., vertebrae). Because of the lack of skeletal preservation of ancient sharks, we must use modern sharks to estimate the size of Megalodon. In order to do this, scientists first determined that an **allometric relationship** (i.e., a relationship of anatomical variables that fits an equation) exists between the **morphology** of a preserved element (i.e., tooth width) and body length in living sharks. Because tooth width and body length are correlated in modern sharks, one can use this allometric relationship to estimate Megalodon's body length by instead measuring the width of Megalodon teeth.

### **Lesson Outline:**

- **Activity 1:** *Worksheet: Megalodon - Biggest Shark that Ever Roamed the Seas*
- **Activity 2:** *Reading Handout: How Megalodon Worked*
- **Activity 3:** *Worksheet: Megalodon Crossword Puzzle*

## Activity 1: Megalodon - Biggest Shark that Ever Roamed the Seas

- Use the *Worksheet: Megalodon - Biggest Shark that Ever Roamed the Seas*

### Procedures:

- This activity begins by getting students of all ages excited about their task of determining the body size of the largest shark that has ever lived.
- An opening inquiry-based discussion should include why complete shark skeletons, including Megalodon, are not found.
- Ask students if they know why this is. (Hint: wiggle your nose and ears for the answer.) Because we don't have complete fossilized skeletons of Megalodon, we must instead look at living sharks as a model.
- Let students know that the Megalodon is the largest shark to have ever lived! Based on the size of Megalodon teeth, we know that this shark was larger than all modern and known, extinct sharks. However, it is difficult to know the exact size of Megalodon, as entire skeletons are not preserved. Estimated to be approximately 60 feet in length, this formidable top predator occupied the world's ancient oceans 2-17 million years ago. Megalodon consumed vast quantities of marine animals and likely contributed to the stability of ecosystems – as top predators do today.
- This discussion can cover all vocabulary words and explain why modern sharks are needed to help us determine the body size of the Megalodon (see *Background Information*).
- Next, students can either work in groups or individually to formulate their **null hypothesis** that “**Modern shark tooth width - does not correlate with body size.**”
- Subsequently, students will begin to graph their data.
- Have students graph tooth width on the x-axis (**independent variable**) and body size on the y-axis (**dependent variable**).
- Once students have completed this task they should be able to conclude that an **allometric relationship - does exist between shark tooth width and body size.**
- Lastly, they are asked to extend their graph to meet the appropriate tooth width of the Megalodon.
- This task will allow the students to estimate the body size of the Megalodon.

### Key Question:

- Is there a predictable relationship between tooth width and body length in modern sharks? **Yes, there is a relationship between tooth width and shark body length.**

### Student Directions:

- Develop a hypothesis to help answer the key question. Use the following data to test your hypothesis. This can be done by graphing tooth width (your independent variable) on the x-axis and body length (your dependant variable) on the y-axis. The first data point has been plotted on the graph. After you have graphed all of the data

in the data table, answer questions 1 & 2. Next, extend your graph to intersect with the Megalodon tooth width of 5.5 inches and determine Megalodon's body length.

### Worksheet Questions

- What is your null hypothesis? **Modern shark tooth width does not correlate with body size.**
- Is it testable and falsifiable? Why or why not? **Yes, it is a testable & falsifiable hypothesis because scientists have already determined an allometric relationship (i.e., a relationship of anatomical variables that fits an equation) exists between the morphology of a preserved element (i.e., tooth width) and body length in living sharks. Because tooth width and body length are correlated in modern sharks, one can use this allometric relationship to estimate the Megalodon's body length, by measuring the width of Megalodon teeth.**
- After graphing your data, is your null hypothesis supported or falsified? Explain. **The null hypothesis is falsified because modern shark tooth width DOES correlate with body size.**
- After extending the graph to meet the tooth width of Megalodon, what is your estimate for Megalodon's body length? **A Megalodon tooth that is 5.5 inches wide should yield a body length estimate of approximately 700 inches (~60 feet long).**

### Activity 2: How Megalodon Worked

- Use the *Reading Handout: How Megalodon Worked*

#### Suggested Discussion Questions:

- How big was Megalodon? **45-60 feet**
- How long ago did Megalodon live? **over 2 million years ago**
- What did Megalodon eat? **other sharks, sea turtles & whales**
- Where did Megalodon live? **in all the seas**
- Who was Megalodon related to? **possibly the great white or mako shark**
- Why is Megalodon important? **it can give us clues to the evolution of sharks**

### Activity 3: Megalodon Crossword: World's Largest Predator

- Use the *Worksheet: Megalodon Crossword Puzzle*

#### Lesson Wrap-up: Discussion Questions:

- ◆ How big was Megalodon? **Scientists estimate - 60 feet in length**
- ◆ Why are complete Megalodon skeletons not preserved? **A shark skeleton is composed of cartilage, which rarely fossilizes.**
- ◆ Can we use modern sharks to help us estimate Megalodon's body size? Why or why not? **Yes, there is an allometric relationship between the width of modern-day shark teeth & size- that can be applied to ancient shark morphology & tooth width.**

### Lesson Extensions:

- Once a size estimate for Megalodon has been determined, a roll of tape (or string) can be cut to represent Megalodon's body length and placed around the classroom. Younger students can instead forgo the graphing activity and construct Megalodon's body length to scale. Additionally, younger students can figure out how many of them (in height) equal one Megalodon (in body length). For more advanced classes, such as high school science or mathematics, a discussion can ensue that touches on the potential uncertainties regarding the Megalodon body length estimate (e.g., what if the graph is not linear with increasing body length and is instead exponential?).

### Further Student Exploration:

- **Carcharodon versus Carcharocles: What's in a Name?**  
A controversy exists because some scientists believe that this species should be classified as a member of the genus *Carcharocles* instead of *Carcharodon*. See: <http://www.elasmoresearch.org/education/evolution/carcharodonvscarcharocles.htm>
- **Book Recommendations**
  - Caroline & Caple / *Giant Shark: Megalodon, Prehistoric Super Predator*
  - Benton, Michael J. / *Vertebrate Paleontology, Third Edition*
  - Cocke, Joe / *Fossil Shark Teeth of the World: A Collector's Guide*
  - Hulbert, Richard C. / *The Fossil Vertebrates of Florida*
  - Renz, Mark / *Megalodon: Hunting the Hunter*
- **Recommended Websites**
  - American Museum of Natural History  
<http://www.amnh.org/exhibitions/permanent-exhibitions/fossil-halls/hall-of-vertebrate-origins/carcharodon>
  - Discovery Education's Prehistoric Sharks  
<http://school.discoveryeducation.com/schooladventures/prehistoricsharks/>
  - Florida Museum of Natural History Website on the Megalodon Exhibit  
<http://www.flmnh.ufl.edu/fish/sharks/fossils/megalodon.html>

### References:

- Modified Lesson from the Florida Museum of Natural History  
An Educators Guide for Megalodon: The Largest Shark that Ever Lived!  
<http://www.flmnh.ufl.edu/files/2513/4664/7890/Megalodon-guide.pdf>
- How Stuff Works: Article - How Megalodon Worked  
<http://science.howstuffworks.com/zoology/marine-life/megalodon.htm/printable>
- San Diego Natural History Museum  
[http://www.sdnhm.org/archive/exhibits/mystery/fg\\_megalodon.html](http://www.sdnhm.org/archive/exhibits/mystery/fg_megalodon.html)
- Fossils Rock! - Crossword Puzzle  
<http://www.fossils-facts-and-finds.com/support-files/megalodon-crossword.pdf>